# A MIXED-METHOD FEASIBILITY STUDY COMPARING THE OUTPATIENT ASSESSMENT OF BURN PATIENTS USING A TABLET DEVICE VERSUS THE USUAL FACE-TO-FACE ENCOUNTER

BY

SUZANNE STEWART MITCHELL

Submitted to the graduate degree program in Nursing and the Graduate Faculty of the University of Kansas in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Chairperson: Sandra Bergquist-Beringer

Carol Smith

Heejung Kim

Ryan Spaulding

Hung-Wen (Henry) Yeh

Date Defended: May 18, 2015

The Dissertation Committee for SUZANNE STEWART MITCHELL certified that this is the approved version of the following dissertation:

A MIXED-METHOD FEASIBILITY STUDY COMPARING THE OUTPATIENT ASSESSMENT OF BURN PATIENTS USING A TABLET DEVICE VERSUS THE USUAL FACE-TO-FACE ENCOUNTER

_____

Chairperson: Sandra Bergquist-Beringer

Date Approved: June 9, 2015

# ABSTRACT

The number of verified burn centers across the U.S. has dramatically decreased, negatively impacting access to burn care. Telehealth is a solution for burn care, however there is minimal research evaluating burn care through telehealth. The primary purpose of this mixed method feasibility study was to examine the reliability of using a Motorola XOOM tablet to perform an outpatient standard burn assessment compared to the usual face-to-face examination. Qualitative information on patients' perception of using the tablet was also evaluated.

A convenience sample of 50 subjects, aged 19 to 76 years, with less than 10% total body surface area burned was recruited from an outpatient burn clinic. Descriptive statistics and the reliability of using a tablet device compared to a face-to-face encounter were measured between modalities, raters, and across raters and modalities using Cohen's Kappa and the Spearman correlation.

The reliability between two raters for the standard burn assessment showed substantial to near perfect agreement for skin graft take (Kappa = 0.892), burn depth (Kappa = 0.731), and cellulitis (Kappa = 0.847) when using a tablet device. The inter-modality reliability by rater showed substantial to perfect agreement for skin graft take (Kappa = 1.0), burn depth (Kappa = 0.848–1.0), and edema (Kappa = 0.876–0.958). The overall reliability of assessing a burn wound through a tablet device was similar to that obtained in face-to-face examination. Spearman correlations between the ratings made by the First Rater and the Second Rater when using a table device ranged from 0.531 to 0.852 and Spearman correlations from the face-to-face encounter ranged from 0.460 to 0.710.

Results from this study provide support for the reliability of a tablet device to assess for burn depth and skin graft take. Findings suggest inconsistency in the reliability of a tablet device to assess the presence of cellulitis, edema and purulence. Tablet device use in burn care can augment the usual, standard face-to-face interaction between patient and provider. Continued research is necessary to further validate its use in early and accurate assessment of burn wounds, burn-related complications, the evaluation of graft take, and the development of hypertrophic scarring.

# ACKNOWLEDGEMENTS

First and foremost, I would like to thank my Chair, Dr. Sandra Bergquist-Beringer. I admire her infinite patience, structured guidance, and unwavering encouragement through this persevering process. I would also like to extend much gratitude to Dr. Carol Smith and Dr. Ryan Spaulding who were instrumental in providing the foundation and expertise in telehealth and telemedicine. I am also grateful for committee members Dr. Hung (Henry) Yeh who provided the essential statistical support necessary from the study design to statistical analysis and Dr. Heejung Kim who provided additional guidance and support.

This study would never have been accomplished without the unimaginable support of the KU Outpatient Burn and Wound Care Center staff and my two collaborating physicians. Leslie, Julie, Jessica, Nancy, Louis, Peggy, Dr. Richard Korentager and Dr. Dhaval Bhavsar offered unequivocal support for my continued education and the execution of my study. I am humbly grateful. Also, to my friends Lynn and Barb, thank you for your interest, continued spirit, and encouragement.

Most importantly, I acknowledge the three most important children in my life: Jordan, Logan, and Jack. Although I wasn't always "fully" engaged, for them I was present. I spent the majority of the last eight years raising 3 beautiful and talented children and accomplishing my greatest academic goal.

## Table of Contents

## LIST OF FIGURES

## LIST OF TABLES

# CHAPTER 1

## Introduction

Approximately 500,000 persons annually experience a burn-related injury, of which 40,000 require hospitalization (American Burn Association, 2005). The management of burn related injuries requires a multi-disciplinary team with expert knowledge in the pathophysiology of burn injury, in-patient management of fluid resuscitation and prevention of infection, as well as outpatient management, and follow-up care including burn rehabilitation and reconstruction. In 2007, there were 125 verified burn centers across the U.S to manage burn related injuries. Each burn unit admitted and treated approximately 200 patients per year and affiliated outpatient burn clinics treated approximately 200 burn visits per month. Verified burn centers have an organizational structure where the burn team consisting of critical care nurses, physical and occupational therapists, a dietician, social worker, case manager, and pharmacist, direct the medical and surgical care of all burn patients. Burn center verification requires the burn center to meet specific, meticulous standards set forth by the American Burn Association (ABA) and the American College of Surgeons (ACS).

Unfortunately, the number of verified burn centers has dramatically decreased over the past several years. In 2015, the number of verified burn centers in the U.S. was only 62, thereby negatively impacting access to burn care. Hospital costs associated with providing care to burn patients (staffing burn surgeons, critical care nurses, physical/occupational/speech therapists, mid-level providers, psychologists, dieticians and case managers), in addition to 1/3 of the patient population being uninsured or underinsured, has placed an unmanageable financial strain on hospitals, contributing to this decline in verified burn centers (ABA, 2007; Klein, Kramer, Nelson, Rivara, Gibran, & Concannon, 2009).

Individuals with a significant burn injury should be referred to the closest verified burn center. A burn injury can be caused by a flame, scald, contact, friction, chemical, or electrical source and result in partial or complete damage to the skin. This injury requires rapid and accurate evaluation, appropriate and timely triage, ongoing assessment, and continuity in follow-up care. Assessment of a burn includes determining the depth of the burn injury, observing for the presence of purulent drainage, presence of a periwound rash, presence of cellulitis, presence of edema, and if grafted, an evaluation of graft take. Burn wound assessment and treatment provided by inexperienced staff will adversely affect patient outcomes including prolonged wound healing, deferred skin grafting, burn wound infection/cellulitis, and hypertrophic scarring and joint contracture with resulting loss of function. Because of the decreased availability of burn centers throughout the U.S., initial burn care and follow-up outpatient care potentially rests with physicians and nurses lacking burn experience and skill. Furthermore, patients discharged from a burn unit who require follow-up burn care, but live a distance from the burn center, may encounter difficulty traveling back to the burn center for weekly outpatient evaluations.

Telehealth is a solution for burn care that facilitates a partnership between providers separated by distance, to promote early diagnosis and triage of the burn patient, expedite safe and appropriate patient transfer to a burn care center and provide continuity in follow-up care. The term, telehealth, was coined in the late 1990s and refers to "the integration of telecommunication systems into the practice of protecting and promoting health" (Maheu, Whitten, & Allen, 2001, p 3). The Centers for Medicaid and Medicare Services (CMS) distinguish telehealth as "the use of telecommunications and information technology to provide access to health assessment, diagnosis, intervention, consultation, supervision and information across distance" but currently only reimburses for real-time, interactive communication. CMS defines telemedicine as "the use

of medical information exchanged from one site to another via electronic communications to improve a patient's health" (http://www.cms.gov/Telemedicine). CMS further defines electronic communication as "the use of interactive telecommunications equipment that includes, at a minimum, audio and video equipment permitting two-way, real time interactive communication between the patient, and the physician or practitioner at the distant site." For the purposes of this paper, telehealth is synonymous to telemedicine and is the preferred term of use.

Two types of technology are predominantly employed in telehealth: store-and- forward technology and video-conferencing. Store-and-forward or asynchronous technology has historically used digital imagery (camera images, x-rays, computed tomography, and ultrasound) to record or "store" information and later send or "forward" this information to a designated health care provider. Asynchronous, or store and forward technology provides flexibility allowing the specialist and the referring provider to send and retrieve information whenever it's convenient for each person (Maheu, et al., 2001). Video-conferencing or synchronous technology typically requires special telehealth equipment to be present at both the "off-site" facility and the "receiving" facility. Interactive televideoconferencing (ITV) is the traditional form of synchronous communication for telehealth programs. In ITV, two or more individuals are physically present in front of video equipment. Both can see, hear and share documents. The specialist can directly interview and examine the patient and perform an interactive consultation with the referring provider to clarify issues. A more innovative form of interactive telehealth, which is significantly less costly than the traditional ITV systems and considerably more mobile, is the tablet device. According to CareHQ, the tablet device is going to revolutionize telemedicine (https://www.facebook.com/media/set/?set=a.400996886609548.89725.309235792452325&type

=3). Market research showed over $700 million in sales related to tablet devices and software in 2011, with projections to reach $2.5 billion by 2018 (http://www.giiresearch.com/report/wg256872-tele-health-carts-servers-monitoring-market-shares.html).

Telehealth offers many advantages to patients, providers, and affected communities. Foremost, telehealth minimizes issues associated with access to care (Myers, Gibbs, Thacker, & LaFile, 2012; Nelson & Gingerich, 2010). Outreach healthcare providers can "tele-conference" from a remote location to receive critical, expert guidance from specialists, in clinical decision-making, evaluation, and management of complex patients. Further, telehealth communication between specialist and referring provider permits the exchange of valuable information for safe and appropriate transfer of care. In addition, it offers the opportunity for professional oversight and guidance to manage care in a patient's home thereby reducing travel for patients and families. Other tangible benefits of telehealth include reduced hospital length of stay, decreased hospital readmission rates, potential reduction in exposure to potential hospital acquired infections, and improved provider and patient satisfaction (Braun, et al.,l.,2005; Chanussot-Deprez, C., & Contreras-Ruiz, J., 2008; Saffle, Edelman, Theurer, Morris, & Cochran, 2009; Sagraves, Bard, Toschlog, & Peck, 2007; & Wallace, Jones, Milroy, & Pickford, 2008). Telehealth applications can also facilitate distance learning and education for medical, nursing, and allied health providers to better serve the community.

## Statement of the Problem

Over the past 15 years, telehealth studies in burn care have confirmed telehealth as a feasible form of technology, however there is minimal research evaluating burn care through telehealth (Wallace, Hussain, Khan, & Wilson, 2012). Wallace et al. (2012) reviewed 24 telehealth studies in burn care conducted from 1993 to 2010. Some of the studies provided evidence that telehealth technology is feasible, with digital image resolutions greater than 1024 x 769 pixels offering no improvement in diagnostic accuracy (Jones, Wilson, & Andrews, 2003; Roa, Gomez-Cia, Acha, & Serrano, 1999; and Roth, Reid, Puckett, & Concannon, 1999). Others evaluated the use of telehealth in clinical decision-making for acute burn care and described enhanced communication between a burn care specialist and non-specialist provider in triaging patients for burn care (Saffle, et al., 2009; Wallace, et al., 2008). The remaining studies performed a cost analysis which were inconclusive but did identify that patients can benefit from increased convenience and substantial cost and time-savings in the outpatient management of burn care.

Despite this supporting evidence, few burn centers have fully embraced telehealth. Holt, Faraklas, Theuer, Cochran, and Saffle (2012) surveyed medical directors of 126 hospitals that provide burn care regarding their use of telehealth. Although 42 of the 50 hospitals that responded to the survey reported that they used telehealth, frequency of use varied widely across facilities from less than 10 telehealth interactions annually to more than 300. Surveyed burn directors reported more experience with the use of digital imagery; only one-third of the burn directors had used interactive video and most of this use was recent, within the past 2 years. Newer technology now allows for easy, accessible, real-time web videoconferencing through a tablet device. At this time, no studies were found that reported the use of telehealth in the

outpatient setting to provide standard follow-up burn care from a tablet device. Inequity in access to quality burn care coupled with affordable hand-held technology provide a synergistic opportunity to improve communication between health care providers and patients, ensure accurate burn diagnosis and optimize burn management, thereby facilitate best patient outcomes.

## Purpose

The primary purpose of this feasibility study was to examine the reliability of using a tablet device to perform an outpatient standard burn assessment compared to the usual face-to-face examination. Qualitative information on patients' perception of using the tablet was also evaluated.

## Research Questions

The following research questions were explored in this study:

1. What is the reliability of a tablet device for performing <u>each component</u> of the Standard Burn Assessment (burn depth, purulent drainage, periwound rash, cellulitis, edema, and if grafted, percent graft take) compared to the usual face-to-face encounter?
    a) What is the inter-rater reliability for <u>each component</u> of the Standard Burn Assessment by modality?
        a1) between raters in a face-to-face encounter?
        a2) between raters using a tablet device?
    b) What is the inter-modality reliability for <u>each component</u> of the Standard Burn Assessment for each rater?
        b1) between a tablet device and face-to-face encounter as evaluated by the First Rater?

b2) between a tablet device and face-to-face encounter as evaluated by the Second Rater?

c) What is the reliability for each component of the Standard Burn Assessment across raters and modalities (tablet device and face-to-face encounter)?

c1) between the First Rater in a face-to-face encounter and the Second Rater using a tablet device?

c2) between the First Rater using a tablet device and the Second Rater in a face-to-face encounter?

2. What is the overall reliability of a tablet device for performing a Standard Burn Assessment (burn depth, purulent drainage, periwound rash, cellulitis, edema, and if grafted, percent graft take) compared to the usual face-to-face encounter?

a) What is the overall inter-rater reliability of the Standard Burn Assessment for each modality?

a1) between raters in a face-to-face encounter?

a2) between raters using a tablet device?

b) What is the overall inter-modality reliability of the Standard Burn Assessment for each rater?

b1) between a tablet device and a face-to-face encounter as evaluated by the First Rater?

b2) between a tablet device and face-to-face encounter as evaluated by the Second Rater?

c) What is the overall reliability of the Standard Burn Assessment across raters and modalities?

c1) between the First Rater in a face-to-face encounter and the Second Rater using a tablet device?

c2) between the First Rater using a tablet device and the Second Rater in a face-to-face encounter

3. What is the feasibility of using a tablet device to perform a Standard Burn Assessment?

4. What are burn patients' perceptions of using a tablet device in burn care?

## Definition of Terms

The definitions of the terms used in this study and their operational definitions are described below. Operational definitions explain how the variables under investigation are observed and measured in the study (Polit & Hungler, 1999).

### Standard Burn Assessment

**Conceptual definition**. A Standard Burn Assessment includes assessment of burn depth, presence of purulent drainage, presence of periwound rash, presence of cellulitis, presence of edema, and if grafted, an evaluation of graft take.

**Operational definition**. Each patient who presented to the outpatient burn clinic received a Standard Burn Assessment. The Standard Burn Assessment includes burn depth (superficial partial, deep partial, and full thickness burn), presence of purulent exudate (yes/no), presence of periwound rash (yes/no), presence of cellulitis (yes/no), presence of edema (yes/no), and if grafted, the percent of graft take, greater than 90% (yes/no).

### Inter-rater Reliability

**Conceptual definition**. Inter-rater reliability is the extent of agreement among clinicians, observers, and raters (Kwet, 2012). Evaluating inter-rater reliability is necessary when answers to questions involve some degree of subjective judgment (based on observations)

(Leech, Barrett, & Morgan, 2008). When measuring categorical or nominal data, there are three approaches to estimating inter-rater reliability: descriptive (percent agreement), coefficients of association (chi square), and correlational statistics (eg. Kappa and Spearman) (Haley & Osberg, 1989; Kwet, 2012). A Kappa statistic is the difference between *observed* agreement compared to how much agreement would be *expected* to occur by chance alone (Kwet, 2012; Viera & Garrett, 2005). Kappa is expressed by the following equation:

$$\text{Kappa} = \frac{proportion\ of\ observed\ agreement - chance\ agreement}{1 - chance\ agreement}$$

Chance agreement is the proportion of agreements that would be expected if the observer's ratings were completely random. Kappa values range from -1 to +1. A kappa value of zero is interpreted as "chance agreement", a kappa value less than zero is interpreted as worse than chance agreement.

Spearman Rho, or Spearman Correlation, a non-parametric correlation measures the strength of correlation between two ranked variables (Kwet, 2012; https://statistics.laerd.com/statistical-guides/spearmans-rank-order-correlation-statistical-guide.php) and appropriate for use in this study because the data are not known to be normally distributed, this assumption of the Pearson correlation may be violated, therefore, the Spearman correlation was used in this study. Assumptions of the Spearman correlation include that two variables are ordinal, interval, or ratio and are ranked. Like the conventional Pearson product-moment correlation, Spearman, ($r_s$) ranges in value from -1 to +1, signaling the strength and direction of the relationship between two ranked variables. Considering $n$ pairs of $(x_i, y_i)$ observations, the observation values are replaced by rankings, and the observations in $x_i$'s and observations in $y_i$'s ($r_{x,i}$ and $r_{y,i}$), use the formula:

$$r_s = \frac{n\sum(r_{x,i}r_{y,i}) - (\sum r_{x,i})(\sum r_{y,i})}{\sqrt{n\sum(r_{x,i}^2) - (\sum r_{x,i})^2}\sqrt{n\sum(r_{y,i}^2) - (\sum r_{y,i})^2}}$$

**Operational definition**. The inter-rater reliability of each component of the Standard Burn Assessment between the telehealth encounter (use of the tablet device) and the face-to-face encounter was assessed by percent agreement and determined by the Kappa statistic. The Landis and Koch reliability scale (Kwet, 2012) can be used to estimate the degree of agreement in this study and was interpreted as follows: 0.10 – 0.20 (slight agreement), 0.21 – 0.40 (fair agreement), 0.41-0.60 (moderate agreement), 0.61- 0.80 (substantial agreement), and 0.81-0.99 (almost perfect agreement).

A Spearman correlation was calculated to determine the overall reliability of a tablet device for performing a Standard Burn Assessment compared to the usual face-to-face encounter. The strength of the correlation was interpreted as follows: at least 0.8 (very strong), 0.6 to 0.8 (moderately strong), 0.3 to 0.5 (fair), and less than 0.3 (poor).

**Feasibility of the Standard Burn Assessment**

**Conceptual definition.** Feasibility refers to a feasibility study which is designed to "try out" or test the adequacy of a research instrument (a tablet device) or plan (Teijlingen and Hundley, 2001).

**Operational definition.** Feasibility was measured by the rater's opinion (yes/no) about their ability to adequately visualize and assess each component of the Standard Burn Assessment (burn depth, presence of purulent drainage, presence of periwound rash, presence of cellulitis, presence of edema, and if grafted, an evaluation of graft take) for diagnosis and clinical decision-making. For "no" opinions, comments to explain the no opinion was also captured.

### Patient Perception

**Conceptual definition.** A patient's perception is an individual's reflection of one's point of view and is usually evaluated in the context of a specific and recent or past experience.

**Operational definition.** A patient's perception of tablet device use for burn care was described through a semi-structured interview, consisting of 7 open-ended questions that occurred during the clinic visit that followed the collection of quantitative data. Usually the follow-up clinic visit occurred within one-week of when quantitative data were collected.

## Significance

The Institute of Medicine (IOM) has heralded for over a decade that health care should be safe, effective, patient centered, timely, efficient, and equitable. According to the 2001 IOM report, "patients should receive care whenever they need it and in many forms, not just face-to-face visits. The healthcare system must be responsive at all times and access to care should be provided over the internet, by telephone, and by other means in addition to in-person visits" (p. 3). This message for equity in access to care was repeated in a recent IOM sponsored workshop to discuss how telehealth can fit in the current health care climate and facilitate improved patient outcomes and reduce health disparities (IOM, 2012).

During the last two decades, marked advancements in technology and high-speed internet access provided a surge in telehealth growth and associated telehealth benefits (improved access to care, better quality care, enhanced communication and reduced costs). Computers that are equipped with a camera device and high-speed internet, the popularity of smart phone technology, and the various available tablet devices afford limitless potential in the telehealth

landscape. This accelerated expansion in technology has occurred at lower cost relative to the high-cost interactive televideo systems.

The emphasis in telehealth growth adopted by several federal government agencies (the Health and Human Sciences, the Department of Defense and the White House Rural Council), are indirectly linked to provisions of the Affordable Care Act (ACA) (IOM, 2012). The ACA improves equity in access to care as availability of resources extends to underserved and rural populations. Increased access to health care for approximately 30 million uninsured U.S. citizens, and expansion of benefits for rural Americans (which is 20 percent of the U.S. population), will place more demands on our health care system. With a limited number of primary care providers and an even more pronounced deficit of specialist providers practicing in rural areas (Gamm, Castillo, & Pittman, 2010; Rosenblatt, Andrilla, Curtin, & Hart, 2005), innovations in telehealth use will play an important role in transforming health care. Telehealth applications can improve patient-provider communication, through a team-based community approach, and thereby improve outcomes.

Currently, there are limited studies evaluating telehealth technology (store-and-forward or video-conferencing) to deliver standard burn care. To the author's knowledge, there are no known studies evaluating the use of a tablet device in burn care or reliability studies comparing providers in a face-to-face examination. To strengthen the telehealth initiative, research needs to document how telehealth technology can be used effectively and efficiently. Burn research needs to demonstrate a telehealth model that implements current standards in burn care and how it can be used in a meaningful way. If telehealth use produces optimal patient outcomes, compared to the usual face-to-face encounter, at a reduced cost, this evidence will support

telehealth as a legitimate mode of health care delivery and influence healthcare policy such that it can become naturally embedded in our health care system.

## Theoretical Framework

The theoretical framework used to guide this study was the Behavioral Model of Health Services Use (BMHSU). Developed by sociologist Ronald Andersen in the 1960's, the BMHSU is a useful framework for understanding access to care and health care outcomes associated with health services' use. In the BMHSU, access is defined as the "actual use of personal health services and everything that facilitates or impedes their use" and means "getting to the right services at the right time to improve health outcomes" (Anderson & Davidson, 1995, p 1).

The BMHSU has undergone several transformations. The most recent version developed in the 1990s (Model 4) describes broad constructs affecting one's use of health services, such as the *environment, population characteristics, health behavior,* and the *outcomes* associated with the use of health services. The "dynamic and recursive nature" (Anderson, R.M., 1995, p 7) of one's *environment, population characteristics* and *health behavior* influence individual *health outcomes. C*haracteristics of the environment and population influence a person's propensity to engage in healthy life-style choices and access health care (health behavior), which has a profound effect on outcomes and consequently, outcomes has an effect on predisposing factors.

The following paragraphs define the concepts within the BMHSU and provided operational definitions applicable in this study (Figure 1). *Environment* was conceptualized as elements of the health care system and leading health policy. Health care system includes the availability of health care resources (facilities, equipment, and the health care organization) and the health care policy decisions that facilitate or act as barriers to access to care. For this study,

e*nvironment* was operationalized through the health care resource, such as telehealth technology, specifically use of a tablet device to deliver outpatient burn assessment.

P*opulation characteristics* are the traits that influence an individual's tendency to use a health service. *Population characteristics* include *predisposing characteristics* (age, gender, race, personal values concerning health), *enabling characteristics* (income, insurance, rural or urban residence, and region of the country), and *need for health services* (severity of illness). For this study, *population characteristics* were operationalized as age, gender, race/ethnicity (*predisposing characteristics*), distance from the clinic (*enabling characteristic*), and burn injury (*need for health services*).

*Health behavior* was defined through one's personal health practices and use of health services (type, site, purpose, and time interval). The type of health service refers to the type of provider or health care specialist (for example, burn physician, nurse practitioner, certified burn/wound nurse). The site of service represents the location where the service was rendered (hospital, hospital-based outpatient clinic, private practice, emergency room, urgent care, or home-health care), and, in this study, an outpatient burn and wound clinic. Purpose for the visit relates to preventative care, illness-related, follow-up chronic disease, or palliative care. For this study, the purpose of the visit was outpatient burn care (initial outpatient burn care and follow-up burn care). Although not measured in this study, the interval of time an individual takes to access the health care system and the frequency of health care visits is important to health care policy-makers. Quantifying when an individual receives initial care, follow-up care, and if necessary specialist referral is paramount to identify fragments in the coordination of care.

*Outcomes* refer to individual perceived health status outcomes, provider evaluated health status outcomes, and satisfaction. For this study, the *primary outcome* was establishing the

*reliability* of using a tablet device (telehealth) to perform a standard burn assessment compared to the usual face-to-face assessment (*provider evaluated health status*). Another outcome is the patient's perception of tablet use to receive burn care. Aday and Anderson (1974) describe an individual's attitude toward the health care system toward "a specific, recent, and identifiable episode… regarding convenience of care, coordination and cost, courtesy shown by caregivers, information given to patients regarding illness, and judgment to the quality of care received" ( p 214). Patient perception of tablet use for convenience of care and care coordination is operationalized though patient interviews that occur after the burn assessment.

Having additional options to receive health care, (for example, a health care system that recognizes telehealth as a viable mode of health care delivery) and a patient's need for specialized health care, (for example, a burn injury), theoretically increases one's propensity to access health care. Improved access to care should improve health outcomes (decreased number of burn-related cellulitis, improved time to heal, appropriate facilitation of burn triage) and enhance patient/provider satisfaction with telehealth. In a future longitudinal study, it will be relevant to quantify time interval data comparing the number of face-to-face encounters to the number of telehealth encounters, and outcome specific data including associated costs.

Figure 1: Theoretical Framework of Access to Care in Burn Patients through Telehealth

## Assumptions

1. Health care specialists are experienced and skilled in burn assessment.
2. Tablet devices function properly.
3. KUMC Bridge is accessible and functional at the time of the patient telehealth visit to allow remote tablet device use.
4. Patients truthfully report their perceptions about tablet use.

# CHAPTER II REVIEW OF THE LITERATURE

Over the past 4 decades, advancements in burn management have accounted for decreased burn mortality in patients suffering from large surface area burns. Despite this, the United States continues to rank highest in the number of fire-related burn injuries and death, in particular with vulnerable populations (children, the elderly and individuals residing in rural populations). Contributing factors likely include loss of verified burn centers across the nation and fewer physicians and nurses competent and skilled in caring for burn patients. A solution to reducing the gap in burn care knowledge and gain expertise minimizing geographical constraints to burn care treatment is telehealth, defined as caring for patients at a distance through real-time video or store-and-forward digital images. This chapter will review standard burn care and access to care issues for the management of burn patients. Then, supporting evidence of the reliability of digital imagery through digital cameras and cell phone technology in burn and wound care are examined. Next, a summary of telehealth research in burn care will describe the benefits of telehealth in caring for burn patients, facilitating triage and in outpatient, follow-up burn care.

## Standard Burn Care

The American Burn Association has established criteria that guide referral to a burn center for in-patient treatment versus outpatient management of a burn (American College of Surgeons, 2006). Although there are hospitals with dedicated burn centers, there is a distinction between a hospital with a dedicated burn center and a hospital with a verified burn center. Burn verification occurs every three years and requires the burn center to meet rigorous standards set forth by the American Burn Association (ABA) and the American College of Surgeons (ACS). A verified burn center has an organizational structure with a designated burn director who is a

board-certified plastic surgeon with a fellowship in burn surgery or 2 years of experience in burn treatment within the past 5 years. As previously stated, the burn unit resources include a multi-disciplinary team experienced in providing current burn treatment from time of injury to rehabilitation. Verification also mandates a minimum of 100 admissions per year, a designated burn operating room available 24 hours per day, an infection control program, weekly patient care conferences, monthly multi-disciplined burn peer review/performance improvement meetings, and a community burn prevention program. Additionally, a verified burn center participates with the ABA burn registry, collecting necessary data for quality and performance improvement and dedicated resources for burn-related research.

Criteria for referral to a burn center for in-patient treatment includes a full-thickness burn greater than 1% total body surface area (TBSA), a partial-thickness burn greater than 10% TBSA, inhalation injury, suspected or known carbon monoxide poisoning (even in the presence of minimal cutaneous burn injury), and burn injuries involving the face, hands, feet or perineum. Other admission criteria include circumferential burns, electric burn injuries and suspected abuse. Circumferential burn injuries require evaluation for compartment syndrome. Although low voltage electric burns (110 to 220 household current) generally do not present as a significant burn injury, there is a risk of cardiac dysrhythmia and therefore 24-hour cardiac monitoring is necessary. Regardless of the extent or depth of the burn injury, a burn injury associated with concomitant vascular or autoimmune disorders may further necessitate admission to a burn center. Peripheral vascular disease and other co-morbidities impede wound healing due to compromised circulation. Patients with autoimmune disorders are usually treated with immunosuppressive medication, which also interferes with wound healing.

**Type of Burn Injury**

A burn can occur through several mechanisms: scald, flame, contact, chemical, and electrical. The temperature of the heat source and the duration of contact with the heat source determine the depth of burn injury. Scald injuries, in particular grease burns, tends to result in deeper tissue injury because water conducts heat 100 times faster than air (DeSanti, 2005). Chemical burns cause injury to the tissue due to alteration in skin pH and disruption of cellular membranes and direct toxic effects on metabolic processes (ABA, 2009). In addition to the duration of contact with the chemical agent, the pH and concentration of the chemical agent will determine the depth of injury. For example, chemical exposure to hydrofluoric acid over a large body surface area can result in death due to hypocalcemia. Electric injuries, termed the "masquerader", are not always immediately visible. The magnitude of injury is dependent on the strength and duration of the current, the pathway of the current and resistance to current flow. Additionally, children and the elderly tend to suffer deeper burn injuries because of thinner subcutaneous tissue. Understanding the mechanism or etiology of the burn injury is essential to understanding burn depth and burn severity.

**Burn Depth and Classification**

The American Burn Association (2009) classifies burn injuries as superficial or epidermal (first-degree), partial thickness (second-degree), and full thickness (third-degree). A burn injury that extends to muscle or bone is termed a fourth degree burn. A burn injury that results in loss of body part or amputation is termed a fifth degree burn. A superficial or first-degree burn involves only the epidermis. The skin appears erythematous and some edema is present. The skin is painful to touch but there is no blistering. Typically, the symptoms of a superficial, epidermal burn subside over 4-5 days (ABA, 2009; Gomez & Cancio, 2007).

A partial-thickness or second-degree burn involves the epidermis and a portion of the dermis, which is comprised of connective tissue and contains capillaries, cutaneous nerves, hair follicles, sebaceous and sweat glands (Johnson & Richard, 2003; ABA, 2009). Partial-thickness burns are further stratified into superficial partial-thickness and deep partial-thickness burn. A superficial partial-thickness burn extends through the epidermis and into the superficial layer of the dermis. The wound appears erythematous due to the dermal layers being inflamed. When gentle pressure is applied to the burn wound bed, the wound bed blanches and has a rapid capillary refill (< 2-3seconds). Within hours, a blister will form. If the blister opens, the wound bed appears wet, pink, and painful, with intact hair follicles and the burn typically heals in 7-14 days. A deep partial-thickness burn extends into the reticular or deep layer of the dermis and presents as a mixed red or waxy white wound bed. Capillary refill may be absent or sluggish. Blisters are usually absent with the wound bed moist to dry, hair follicles may not be intact, and the burn is less painful although sensation should be intact. A deep-partial thickness burn takes longer to heal, typically 14-21 days or even longer if there are concomitant factors (diabetes mellitus, tobacco use, or development of infection).

A third degree or full-thickness burn extends through the epidermis, dermis and into the subcutaneous tissue (Johnson & Richard, 2003). Third degree burns present with a leathery white eschar without hair appendages and are insensate. Additionally, intrinsic factors (diabetes mellitus, peripheral vascular disease) and extrinsic factors (tobacco use) compromise wound healing and are responsible for a partial thickness burn converting to a deep partial thickness burn and a deep partial thickness burn converting to a full-thickness burn.

There are three zones of injury that determine if a burn transitions from a partial thickness to a full thickness and vice versa: the zone of coagulation, the zone of stasis, and the

zone of hyperemia. The zone of coagulation is the central burn area of devitalized tissue (burn injury closest to the heat source). The zone of stasis includes marginally perfused tissue (ischemic tissue at risk of becoming necrotic). The zone of hyperemia includes the outlying tissue (capillary vasodilatation and inflammation) (Gibran & Heimbach, 2000; Sargent, 2006). It typically takes 3 to 4 days for a burn to declare itself or reach its full depth. During the early phase of injury, marginally perfused tissue in the zone of stasis could convert to a zone of coagulation (full thickness depth) or recover to the zone of hyperemia. The extent of the burn injury determines whether epithelialization will occur spontaneously or if skin grafting is necessary to close the full-thickness burn wound.

Accurate burn assessment is crucial to prescribing appropriate treatment and is dependent upon the experience of the provider and the timing of diagnosis relative to the burn injury evaluation. As previously stated, it can take up to 4 days for a burn injury to declare itself. Therefore, a burn may appear as a superficial partial-thickness burn on day 1 but then convert to a full thickness burn by day 3. Differentiating between a deep partial thickness and full thickness burn may not be easily discernible. However, after two weeks of managing a burn injury, an experienced provider should determine that the burn injury should heal over the next 7-10 days or require excision and skin grafting (Hartford & Kealey, 2007).

Beyond assigning burn size and depth, a burn must be evaluated for infection. Burn wound infections include local cellulitis, burn-related surgical infection, and invasive wound infections of unexcised burns (Church, Elsayed, Reid, Winston, & Lindsey, 2006). Infection can cause a delay in epithelialization leading to hypertrophic scarring. Cellulitis is characterized by extension of erythema beyond the burn injury, involving adjacent uninjured skin, and may include at least one other manifestation: increased warmth, tenderness, swelling, or signs of

lymphangitis/lymphadenitis. A burn wound infection has similar characteristics of a localized cellulitis however will be marked by dramatic changes in the wound bed appearance. There will be separation in the wound bed eschar or marked discoloration (brown or black), malodor, purulent drainage, and bacterial invasion marked through microscopic examination.

**Access to Burn Care**

Access can be defined in several ways, through population characteristics (personal income and health insurance coverage), the health care delivery system, geography, and through outcomes (for example, satisfaction scores) (Aday & Anderson, 1974, p 207). Anderson defined access further. Access to health care is characterized by the "actual use of personal health services and everything that facilitates or impedes their use…getting to the right services at the right time to improve health outcomes" (Andersen & Davidson, 1995, p 1). In burn care, in-patient and outpatient burn management is shaped by geographical constraints and the limitations within the health care system. Care of a patient hospitalized for a burn injury is dependent on specialized care by dedicated burn staff. A decline in the number of verified burn centers across the United States has led to long distance transfers, potential delay in treatment, and inadvertent suboptimal care through inexperienced providers. Outpatient burn clinics associated with an in-patient burn unit also require expert clinic staff committed to providing care to a population with unusual and often long term needs.

**Access to Care Issues for In-patient Burn Management**

Several studies have described geographic influence on the delivery of burn care including the disparity between referring providers and burn specialists in burn assessments and its effects on burn outcomes (Klein, Nathens, Emerson, Heimbach, & Gibran, 2007; Klein, et al., 2009; Guagliardo, Jeng, Browning, Bilodeau, Dimick, & Hickerson et al., 2008). There are only

62 verified burn centers across the U.S. (http://www.ameriburn.org/verification_verifiedcenters.php), thus some patients who meet burn admission criteria require transportation up to hundreds of miles or even thousands of miles (for Alaskans) to reach a verified burn center in their region (Klein, et al., 2007). Before deciding to transport a patient long distance, specific patient information (for example, size and depth of the burn) needs to be accurately communicated to the receiving burn facility to ensure appropriate and safe transfer.

To evaluate the safety of and need for long-distance transfers, Klein et al. (2007) retrospectively analyzed data on burn patients who were transferred more than 90 miles to the University of Washington Burn Center for definitive burn care. Two outcome indicators of interest were the duration of transport and estimation of burn size, both important indicators to evaluate the patient transfer process. Duration of transport was measured as the time from burn injury to arrival at the burn unit by ground or air. The difference between the estimated burn size and the actual burn size were stratified by percent total body surface area (0-10, 11-20, 21-30, 31-40, and greater than 40) and compared using a paired t-test.

Study data showed there were 1877 admissions to the University of Washington burn center between 2000 and 2003. Of these, 949 (51%) patients were transferred to the burn center from outside facilities. Among the 949 transferred patients, 424 (45%) patients were transferred from a distance of at least 90 miles. The average transport time was 7.2 hours with the majority of patients transported by air (66%). Most of the transferred patients were male. Less than 20% suffered an inhalation injury. Overall, physicians in the referring facilities significantly overestimated the burn size compared to the actual burn size determined by experts at the burn center (referring estimate of 22.8% mean TBSA compared to the actual burn size of 16.7% mean

TBSA, ($p < .001$). When stratified by burn size (0-10%, 11-20%, and 21-30%), there was a significant difference in burn size estimations ($p < .001$). Among patients with a burn less than 15% TBSA (as determined by the burn center), referring providers estimated burn sizes greater than 20% of the actual burn size in 22 patients and estimated a burn size of 50% in 2 patients with an actual burn size of 15%. Errors in burn size estimation can lead to inappropriate burn center referral, and under and over-fluid resuscitation, potentially inappropriate intubation, the development of compartment syndrome and delay in escharotomy. Despite the significant differences in estimation of burn size, there were no patient deaths and minimal transport complications. Findings support the need for outreach education on burn size estimation and support the role of telehealth in facilitating initial burn management and triage.

In a related study, Klein et al. (2009) examined access and appropriate triage to verified and non-verified burn centers across the U.S. for individuals who reside within 1-2 hours of the facility by air transport and 1-4 hours by ground transport to a regional burn center. The study was important because initial estimation of the burn injury (TBSA), airway assessment, and fluid resuscitation are crucial to optimizing patient outcomes. At the time of the study, there were 51 verified burn centers in the U.S. and 128 non-verified burn centers. By ground transportation, 25% of the population lived within 1 hour of a verified burn center, 46% within 2 hours, and 68% within 4 hours of a verified burn center, leaving 33% of the population over 4 hours away from a verified burn center. When evaluating access to any burn center (verified and non-verified), 41% of the population resided within 1 hour of ground transportation, 68% within 2 hours, and 91% within 4 hours of the burn center. By air transportation, 54% lived within 1 hour and 79% lived within 2 hours of a verified burn center, whereas 75% of the population resided within 1 hour of any burn center (verified and non-verified), and approximately 94% resided

within 2 hours. Access to a verified or non-verified burn center for ground and air transport was highest in the Northeast and lowest in the South. At the state level, there were 18 states without 2 hour ground access to a verified burn center. In the West, none of the residents of Montana and North Dakota were within 2 hours of a verified or a non-verified burn center, by either ground or air.

These studies plus others described inequity in access to burn care, particularly for the West and South regions of the U.S. (Guagliardo et al., 2008). The most important facilitator for the development of health services and outcomes research, the Dartmouth Project, empowered hospitals to explore their patient demographic discharge data in order to identify problems and solutions (Guagliardo et al., 2008). This stimulated the American Burn Association to issue a "call for data" on burn outcomes research. Hence, the National Burn Repository (NBR) was formed from verified burn centers. Using NBR data between 1995 and 2005, information on where patients were burned and treated were collected to identify inefficiencies and inequities in access to burn care. Data collected included the number of residents within each state that were treated in another state and the number of patients received by a state who resided in another state. The analyses revealed there over 8000 burn admissions occurring across state lines. South Carolina, Mississippi, Wisconsin, and Florida had the largest number of residents who were treated for burns outside of their state. When adjusting for state population, South Carolina, New Hampshire, North Dakota, and Mississippi ranked highest in number of individuals who required burn care outside of their respective state. In contrast, Georgia received the highest number of out-of-state burn patients (36%) mostly from South Carolina, followed by Alabama (12%) who received a significant number of patients from Mississippi. Minnesota (9%) received a significant number of patients from Wisconsin, Massachusetts (8%) received a significant

number of patients from New Hampshire, and Kansas (6%) received a significant number of patients from Missouri. Overall, many individuals had to cross state borders for burn care due to a lack of in-state burn facilities. Improving access to care in these underserved areas can result in better quality care and improved patient outcomes.

**Access to Care Issues for Outpatient Burn Management**

Patients who do not meet criteria for admission are managed in an outpatient burn clinic. According to the American Burn Association (ABA) criteria, all verified burn centers must be partnered with an outpatient hospital-based burn clinic. Outpatient burn management includes weekly re-assessment of the burn wound, as well as evaluation of the patient's comfort with dressing changes, pain management, and eventually scar management. As long as the wound is stable (showing signs of healing and no evidence of infection) and the patient has verbalized understanding of wound care, then weekly intervals are appropriate (Hartford & Kealey, 2007). The primary objective in outpatient burn care is to have all burn wounds healed in one month. Burn wounds that heal spontaneously in three weeks have little incidence of hypertrophic scarring (thick, raised, red, sometimes pruritic scar) and minimal pigmentation issues. Burns that take longer than three weeks to spontaneously heal are more likely to develop hypertrophic scarring, unstable scars (frequent reopening) and hyper/hypopigmentation. Patients who are discharged from the in-patient burn unit also receive follow-up burn care in an outpatient burn clinic. This care occurs over the next several weeks, months to years depending on the extent of the burn injury and need for rehabilitation and burn reconstructive surgery.

Besides the geographic issues, a decline in home health agencies has rendered access to burn care inequitable. More than 2700 home health agencies closed in the late 1990s secondary to reduced reimbursements (Kobza & Scheurich, 2000). Ongoing cuts in Medicaid

reimbursements have further reduced their numbers. An estimated 12 million U.S. residents require home health care services and 25% of home health agencies are located in rural America. These rural home health agencies are often funded by small, not-for-profit hospitals and face significant challenges and barriers in sustainability with regulatory and financial constraints (Nelson & Gingerich, 2010).

Adding complexity to the situation, there is a shortage of wound and ostomy nurses in home health agencies, imparting further obstacles and hurdles in continuity of care (Litzinger, Rossman, Demuth, & Robets, 2007; Moore, 2008). There are currently three organizations credentialing nurses in wound care (the National Alliance of Wound Care, the Wound, Ostomy, Continence Nursing, and the American Board of Wound Management) (www.nawccb.org/wound-care-certification-comparison). Although each organization has documented the number of certified nurses (the National Alliance of Wound Care with 14,000, the Wound, Ostomy, and Continence Nurse society with 6500, and the American Board of Wound Management with 3200), it is difficult to accurately reflect the number of practicing wound care nurses. The actual number of practicing WOCNs is less than the number of certified nurses because the certified number includes retired nurses, nurses who work part-time, and nurses not involved in direct patient care (Moore, 2008).

The quality of the rural health care delivery system is determined by the availability and ability of providers and health care facilities to give care to rural residents that is needed and effective in generating positive health outcomes (Gregg & Moscovice, 2003; Rosenblatt, 2002). The lack of primary care providers and a more pronounced deficit of specialists in rural locations has rendered “access to care” inequitable. Inconsistency in burn assessment, and decreased use

of advanced wound products (due to lack of knowledge and lack of availability) lead to poor healing times, increased number of home health nursing visits, and increased health care costs. Telehealth is a mechanism to augment limited human resources and improve equity in access to specialized burn care.

**Digital Imaging and Reliability of Digital Images**

The most common feature of telehealth is use of the digital image. A digital image is composed of picture elements called pixels. Resolution is "the ability to distinguish fine spatial detail" and is expressed as the number of dots per inch (dpi), pixels per inch (ppi), or lines per inch (lpi) (http://www.library.cornell.edu/preservation/tutorial/intro/intro-02.html; Sitts, 2000). A digital image is expressed by multiplying the pixels per inch by the number of pixels horizontally and the number of pixels vertically. For example, a 5x7 image with 300 ppi would have 1500 pixels x 2100 pixels. The baseline resolution for diagnosis from a digital image is 768 pixels x 512 pixels (Bittorf, Fartasch, Schuler, & Diepgen, 1997). A higher resolution of 1536 pixels x 1024 pixels offers greater magnitude and focus without loss of clarity or sharpness. Bit depth refers to the number of bits used to define each pixel's color. A 1-bit image refers to a bitonal image (black or white). A 2-bit image refers to a grayscale. A color image typically requires 8-24 bits. Compression is used to reduce an image for storage, processing, or transferring and it is better to utilize a standard or commercial compression technique, such as JPEG (http://www.mnhs.org/preserve/records/electronicrecords/erdigitalimaging.html). Q refers to the compression of the image and the number refers to the quality of the image. For example, a Q=100 is the full image quality, a Q=50 is average image quality and low compression, and a Q=1 is the lowest image quality and highest compression.

**Digital Imaging Using Digital Camera**

A number of studies have substantiated the reliability of using a digital image from a digital camera for diagnosing and treating burns and chronic wounds (Jones et al., 2003; Murphy, Bain, Wassen, Wilson, & Okunski, 2006; and Roth, Reid, Puckett & Concannon, 1999). These studies also delineated the required pixel strength and amount of compression necessary (JPEG format) to maintain integrity of the digital image without compromising resolution (Galdino, Vogel, Vander Kolk, 2001; Roa et al., 1999). Table 1 provides an overview of studies evaluating the reliability of digital camera images in burn and wound care.

In 1999, Roth et al. evaluated the reliability of evaluating and treating wounds using images digitized from a 35mm slide. The authors selected 24 images of different types of wounds (pressure ulcers, traumatic wounds, burns, and infected wounds) on 35 mm slides and digitized these images with resolutions set at 640 x 425 pixels and stored them as JPEG files. The purpose of the study was to compare the physician's ability to evaluate, diagnose and appropriately treat wounds after viewing either a low-resolution digital image or a 35 mm slide image of the same wound. Six physicians examined the 24 wounds initially in a digital format and then on a 35 mm slide. The six physicians included a board certified plastic surgeon, chief plastic surgery resident, chief general surgery resident, 4$^{th}$ year plastic/general surgery resident, and a surgical intern. Using the digitized and 35mm slide images (total of 48 images), each physician answered five broad questions regarding wound characteristics: is the wound clean, infected, healthy granulating base, require skin grafting, or need a tissue flap? The time interval between viewing the digital image and the slide image was not defined.

The data was initially analyzed for overall agreement between the digital image and the slide image of the same wound. Among all raters, there was 87% agreement ($p < .0004$) between

Table 1
*Studies Evaluating the Reliability of Use of a Digital Camera*

| Authors | Year | Place | Sample Size | Design | Technology | Variables | Statistics | Findings |
|---|---|---|---|---|---|---|---|---|
| Roth, Reid, & Concannon | 1998 | U.S. | 24 | Feasibility, comparing low resolution digital image to 35mm to evaluate and treat wounds | S-F 640 x 425 pixels, digitized images from 35mm slide | Is the wound clean, infected, granulating, require graft, or flap | Percent Agreement and Kappa value | 87% agreement overall; Moderate Kappa values 0.50 – 0.80 |
| Roa, Gomez-Cia, Acha, & Serrano | 1999 | Spain | 38 | Feasibility evaluating acceptable degree of compression to maintain image quality and diagnose burn depth | S-F Canon Shot 600 digital camera, Q=10,Q=30, Q=50 degree of compression | Provide burn depth diagnosis and rate with a degree of certainty, 1 (least certain) to 5 (most certain) burn depth, (superficial, partial, or full thickness | Percent agreement | 90% agreement between non-compressed image and Q=50 compression, 78% agreement in diagnosis with Q=10 compression |

*S-F = store and forward telehealth technology

Table 1 continued

| Authors | Year | Place | Sample Size | Design | Technology | Variables | Statistics | Findings |
|---|---|---|---|---|---|---|---|---|
| Jones, Wilson, Andrews | 2003 | U.K. | 60 | Feasibility, assessed reliability of diagnosing burn depth from varying degree of compression compared to a FTF assessment | S-F Nikon Coolpix 995 digital camera, 1024 x 768 1600 x 1200 2048 x 1536 | Burn depth, cellulitis, infection, edema; quality of the three different compression files for sharpness, color, exposure | Kappa value | Overall Kappa value 0.60 for burn depth, infection (0.42), cellulitis (0.40), erythema (0.47), edema (0.40). No improvement in reliability with file size greater than 1025 x 768 pixels/2.25 Mbytes |
| Murphy, Bain, Wassen, & Wilson | 2006 | U.S. | 56 | Feasibility, comparing FTF assessments of wounds with assessments of same wounds from digital image | S-F Sony S 35 mm 3.3 megapixel | Eschar, exposed bone, cellulitis, purulence, pitting edema, granulation color, & depth | Kappa value | Almost perfect agreement Kappa value 0.845 to 0.988, except for depth 0.661 |

*S-F = Store and Forward Telehealth Technology
FTF = Face-to-face

the digital image and the slide image on the wound characteristics. Because the test for homogeneity was rejected, individual rater agreement between the digital image and the slide image was measured using the Kappa statistic. Also, a correlation determined by percent agreement doesn't account for those instances when two or more raters would "agree" or "disagree" by chance (Kraemer, Periyakoil, & Noda, 2004).

There were six images the physicians shared 100% agreement and four images with less than 75% agreement. The Kappa values ranged from 0.50 (the surgical intern) to 0.88 (the board-certified plastic surgeon), with a significant correlation between higher Kappa values and increased years of experience, ($r = .93$, $p = .007$). The authors did not determine which type of wound or wound characteristic increased or decreased the inter-rater reliability. The acceptable degree of compression to maintain image quality in telehealth communication was evaluated by Roa et al. (1999). Using a digital Canon Power Shot 600 camera, Roa took 38 digital images of burn wounds from 22 consecutive burn patients. Launched in 1996, the Canon Power Shot 600, with 0.5 megapixels and a resolution of 832 x 608 pixels was one of the earliest consumer digital cameras available in the US (http://www.canon.com/camera-museum/camera/dcc/chrono_1995-2000.html). The purpose of the study was to determine which degree of compression would preserve the image quality and allow a burn specialist to accurately diagnose burn depth, compared to a face-to-face examination. Burn images were compared at Q=10/highest compression and lowest image quality, Q=30/average compression and average image quality, Q=50/lowest compression and good image quality, and a non-compressed image/ best image quality.

In this study, all photographs were taken by the same person using a standardized protocol for photography: the distance between the camera and the burn area was 15-60 cm, the

image was always taken with a flash against a homogenous background (blue or green), and the camera was positioned parallel to the burn area. The authors reported a 90% agreement on the diagnosis of burn depth between a digital image at Q=50 degree of compression and a non-compressed image compared to 78% agreement with a Q=10 compression. In addition, the authors were almost completely certain (mean certainty 4.21) of their diagnosis using the Q=50 compression, compared to Q=10 compression (mean certainty 3.0). However, the accuracy and confidence in burn depth diagnosis diminishes as degree of compression increases.

An unknown number of "burn experts" (burn surgeons, burn nurses, and medical trainees in plastic and reconstructive surgery) were asked to view the images and provide a burn depth diagnosis (first-degree, superficial partial thickness, deep partial thickness, or full thickness) and rate their degree of certainty (1=least certain to 5= most certain) on the burn depth diagnosis. Each expert was also provided information regarding the patient's age, etiology of the burn (scald, flame, electric, chemical), and burn location. These interpretations were compared to a face-to-face exam which occurred one week later. The natural evolution of a burn injury dictates that the burn wound appearance on day 1 will be different compared to day 7. To reduce this potential threat to validity in the future, the confirmation diagnosis (the face-to-face examination) should be performed the same time the digital images were obtained.

Further investigation of the reliability of assessing burn depth from varying degrees of compression using a digital image was examined by Jones, Wilson, and Andrews (2003). Using a Nikon Coolpix 995 digital camera, 60 burn wounds from 60 patients were assessed in person and compared to a digital image at three different resolutions and corresponding file size: 1024x768 pixels/2.25 Mbytes, 1600x1200 pixels/5.5 Mbytes, and 2048x1536 pixels/9 Mbytes. In general to determine the appropriate file size (Mbytes), the number of pixels is multiplied

times three (representing the colors red, blue, and green) (http://www.nhphotography.com/what-is-image-size.htm). The majority of the burns were scald (16), contact (13), or flame (11), with the remaining burns caused by chemical (7), flash (5), electrical (3), sunburn (3), frostbite (1), and friction (1). Most of the participants were Caucasian (56) with 3 Asian and 1 Black.

The face-to-face examination and the examination from the digital image were performed by the same person. The interval between the in-person and digital assessments was 4-6 weeks, which would minimize inter-rater bias that might occur if the assessments are performed close together in time. Burn depth was classified as superficial, partial-thickness or full-thickness. Partial-thickness burns were further categorized as (1) superficial, (2) partial, or (3) full thickness. In addition to burn depth, the burn wounds were evaluated for the presence of infection, cellulitis, and edema. The observer also evaluated the quality of the three different resolutions for appropriateness of viewpoint, sharpness and color (5-point scale, 1=very poor; 5=excellent) and exposure (5-point scale, 1=very light; 3=correct; 5=very dark). The images (the three different file sizes and the face-to-face encounter) were cross tabulated in SPSS and agreement between the assessments was measured using a Kappa value.

Overall, there was moderate agreement (Kappa value = 0.6) on burn depth between the face-to-face and digital image rating from an image with 2.25 Mbytes size and a 5.5 Mbytes size. Partial-thickness burns showed the lowest agreement with a Kappa value of 0.45 (2.25 file), 0.32 (5.5 file), and 0.25 (9.0 file). The results show that a burn image with a file size of 2.25 Mbytes (1024 x 768 pixels) provided as much consistency in agreement as a face-to-face assessment. Kappa values for infection, cellulitis, erythema, and edema showed fair to moderate agreement, with scores of 0.42, 0.40, 0.47, and 0.40 respectively. Unlike Roa (1999), Jones et al. found the reliability of assessing burn depth consistent across file sizes. However, Jones did not provide an

operational definition for wound erythema, infection, and cellulitis which could account for low Kappa values

With the explosion of digital technology and the plethora of digital cameras, Galdino et al. (2001) recognized that varying digital cameras produce varying digital images. They tested five digital cameras (Nikon Coolpix 950, Nikon D1, Olympus C 2500, Olympus 600-D, and Sony DSC-D700) to standardize how digital images are taken, in particular those images used in medical and nursing journals and presentations. The authors explored the different variables that affect the quality of the digital image (lighting conditions) and how the image is processed by the camera (camera settings). Ultimately, Galdino provided the following guidelines for standardizing digital photography to accommodate ease of use: 1) maintain consistency, use the same camera, camera settings and lighting, 2) use the matrix metering setting which automatically controls for color, contrast, and lighting characteristics, 3) use gray cards to ensure balanced color, 4) use ISO default setting which automatically adjusts the camera's sensitivity to light, 5) use a blue or green background, 6) use resolutions between 1.5 and 2.7 million pixels, 7) use compression of medium to high quality, and 8) and images taken 18-24 inches from wound.

Murphy et al. (2006) used Galdino's (2001) recommendations to compare face to face assessments of wounds with assessments of these same wounds from a digital image taken with a Sony S 35 3.3 megapixel digital camera. Wounds were assessed for eschar, exposed bone, cellulitis, purulence, pitting edema, granulation color, and depth. There were two phases of the study with modifications occurring in the second phase to improve reliability. There were 5 board-certified vascular surgeons, 2 board-certified plastic surgeons, and a 3$^{rd}$ year plastic surgery resident that participated in the first phase of the study. In the second phase, 2 board-

certified vascular surgeons, 1 board- certified plastic surgeon, and a 5th year plastic surgery resident participated in the study.

In phase 1, a vascular surgeon and the plastic surgery resident assessed the wound in person. The plastic surgery resident took two digital images of the wound and the vascular surgeon verified that the digital images accurately reflected the wound as assessed during the face-to-face physical exam. The vascular surgeon and the plastic surgery resident then completed a questionnaire on the wound characteristics, although the time interval between the assessment and completion of the questionnaire was not disclosed. The questionnaire required a yes/no response to the following wound characteristics: eschar, exposed bone, cellulitis, purulence and swelling. Granulation was categorized as 0-25%, 26-50%, 51-75%, and 76-100%, color as pale, pink or red/bleeding, and depth as 1-2mm, 3-4mm, and 5mm or more. The digital images were viewed by a plastic surgeon (who had not performed the face-to-face examination) at a distant location. Inter-rater reliability was measured between the plastic surgeon, vascular surgeon, and the resident. Kappa values for each wound characteristic ranged from 0.502 to 0.871, showing moderate to substantial agreement.

To improve the reliability of the results, the number of surgeons participating in the assessments decreased from 8 to 4 in the second phase of the study and a more experienced plastic surgery resident (5th year) replaced the 3rd year plastic surgery resident. Furthermore, only one picture was taken and the questionnaire was modified to include “pitting edema” instead of “swelling”. These changes in addition to pre-study instructions on the questionnaire and requirement to complete the questionnaire at the time of the examination likely contributed to improved kappa values. Kappa values for each variable (except for depth, 0.661) ranged from

0.8452-0.988, showing almost perfect agreement between raters. The authors felt that kappa values in the range of 0.80 to 0.90 were required to ensure appropriate medical care.

**Summary of Digital Imaging Using Digital Camera**

Over the past 15 years, the digital camera has evolved with enhanced pixel strength and resolution, establishing consistency in diagnosis of burn and wound images between the digital images compared to a face-to-face examination. The 1996 Canon Powershot digital camera with 0.5 megapixels allowed for 90% agreement between a digital image and a face-to-face image. A decade later, the Sony S 35 digital camera with 3.3 megapixels produced near perfect Kappa values when physicians were evaluating wounds. Although there hasn't been a plethora of studies evaluating the reliability of diagnosing burn depth or burn wound characteristics from a digital camera (Roa, et al., 1999; Jones et al., 2003), the previous studies have documented substantial reliability values with the use of a digital camera in characterizing burns and wounds. The next section will summarize the reliability of using images from a cell phone camera to reliably diagnose burns and wounds.

**Digital Imaging Using Cell Phone Camera**

Over the past two decades, cell phone technology has rapidly evolved from the obsolete 1G and 2G network to the expansive 4G network. Cell phone camera devices advanced from 1 megapixel to 5 megapixels and smart phone capabilities provided individuals with mobile internet access. More recently, cell phones have been employed in telehealth programs for early diagnosis and definitive treatment in burn and wound care (Braun,Vecchietti, Thomas, Prins, French, et al., 2005; Engel, Huang, Tsao, Lin, Chau, et al., 2011 ; Hsieh, Tsai, Yin, Chen, Yang, et al., .2004; Pirris, Monaco, Tyler-Kabara,2009; and Shokrollahi, Sayed, Dickson, & Potokar, 2008; Tsai, Pong, Liang, Lin, & Hsieh, 2004). Most of the studies using cell phones were plastic

surgery cases involving soft tissue injuries of the hand (Hseih et al., 2004), lower extremity wounds (Tsai et al., 2004; and Braun et al., 2005), or evaluation of free flaps (Engel et al., 2011). Table 2 provides a compilation of these studies evaluating the use of camera cell phones to diagnose and treat burns, chronic wounds, and soft tissue injuries.

In the study by Hsieh et al. (2004) almost a decade ago, a group of plastic surgeons evaluated the feasibility of using a cell phone camera for triaging soft tissue injuries of the hand. The study population consisted of 45 individuals who presented to the emergency room with a total of 81 soft tissue hand/digit injuries. The soft tissue hand injuries were triaged by an emergency room surgical resident using a Panasonic cell phone equipped with an 110,000 pixel camera into one of three treatment groups. In group 1, the wound could be managed conservatively with secondary wound healing or primary closure. In group 2, the soft tissue injury required skin grafting or local flap closure. In group 3, the soft tissue injury required microsurgery with replantation or free flap coverage. The digital images were sent to another mobile camera phone held by the consulting plastic surgery physician for review. The patient's trauma and medical history were communicated to the consulting plastic surgery physician via the cell phone. The consulting plastic surgery physician examined all the patients face-to-face in the emergency room shortly after the initial telehealth consultation and prescribed appropriate treatment based on the face-to-face exam. Triage management from the emergency room surgical resident was compared to the consulting plastic surgery physician's face-to-face exam. Additionally, the digital images were examined by three plastic surgery residents (either in their first or second year of training) who also assigned the patients into a triage group, assessing for skin defects and bone exposure. The plastic surgery residents' triage management was compared to the consulting plastic surgery physician's face-to-face examination.

Table 2
*Studies Evaluating the Reliability of Camera Phones*

| Authors | Year | Place | Sample Size | Design | Technology | Variables | Statistis | Findings |
|---|---|---|---|---|---|---|---|---|
| Hseih, Tsai, Yin, Chen, Yang, et al. | 2004 | Taiwan | 81 | Feasibility, use of camera phone to evaluate soft tissue injury of hand | S-F Panasonic GD 88 cell phone 110, 000 pixel | Soft tissue hand injury into treatment group; skin defects and exposed bone | Percent Agreement, Sensitivity, Specificity | 85% agreement in triaging soft tissue hand injuries into appropriate treatment group. 71% specificity; 79% sensitivity for skin; 75% specificity for bone and 76% sensitivity for bone |
| Tsai, Pong, Liang, Lin, & Hseih | 2004 | Taiwan | 60 | Feasibility evaluated the reliability of using a mobile camera phone to diagnose and treat lower extremity wounds | S-F Panasonic GD 88 camera phone with 110,000 pixels | Presence of necrosis, gangrene, erythema, cellulitis, infection, need for ABX or need for surgery | Percent Agreement, Kappa, Sensitivity, Specificity | Erythema had lowest kappa 0.44, followed by necrosis with 0.58, cellulitis of 0.61, and gangrene with 0.73. Erythema had the lowest percent agreement of 66%, followed by cellulitis with 74%, then necrosis with 76% and gangrene with 80% |

*S-F = Store and Forward Telehealth Technology

Table 2 continued

| Authors | Year | Place | Sample Size | Design | Technology | Variables | Statistics | Fingings |
|---|---|---|---|---|---|---|---|---|
| Braun, Vecchietti, Thomas, Prins, & French, et al. | 2005 | Switzerland | 61 | Feasibility, FTF evaluation of chronic wounds compared to two remote physicians using mobile camera phone | S-F Nokia 7650 camera phone 310,000 pixels | Granulation, epithelialization, fibrin, necrosis, periwound descriptors | Kappa value | FTF compared to Physician 1=0.82; FTF compared to Physician 2=0.74; Kappa b/w Physician 1 and 2 =0.75; Erythema had highest kappa 0.94 and 0.92 for Physician 1 and Physician 2 respectively; Granulation had lowest kappa 0.69 for Physician 1; Necrosis had lowest kappa 0.49 for Physician 2. |
| Pirris, Monaco, Tyler-Kabara | 2010 | Spain | 3 | Case study, evaluated the use of cell phone to treat neurosurgical patients | Store and Forward Camera Phone | | none | |

*S-F = Store and Forward Telehealth Technology;
FTF = Face-to-Face

Table 2 continued

| Author | Year | Place | Sample Size | Design | Technology | Variables | Statistics | Findings |
|---|---|---|---|---|---|---|---|---|
| Engel, Huang Tsao, Lin, Chou, et al. | 2011 | Taiwan | 3024 | Feasibility examined smart phone technology to evaluate flap of head, neck, chest or extremities | S-F, iPhone, 2 megapixel camera | Flap compromise rated as healthy, arterial insufficiency venous congestion, response time, inter-rater reliability between surgeons | Percent Agreement | Accuracy between in-person and smart-phone was high 98.7% and 94.1% respectively. High inter-rater reliability between smartphone assessors. Rate of re-exploration similar between groups but smartphone group higher flap salvage rate and success rate. |
| Shokrollahi, Sayed, Dickson, & Potokar | 2007 | UK | 31 | Feasibility evaluate use of camera phone in patients with less than 10% TBSA burn | S-F Nokia 7610 1 megapixel camera | Burn depth, and size | Correlation coefficient | Strong correlation between digital and face-to-face with TBSA high-percent agreement in assessing burn depth |

*S-F = Store and Forward Telehealth Technology

When comparing the surgical resident's triage recommendation to the recommendations made by the consulting plastic surgery physician in the face-to-face evaluation, the surgery resident correctly assigned 69 of the 81 soft tissue injuries into the appropriate triage group (85% agreement). Comparison of the three plastic surgery resident's telehealth triage recommendations to the consulting plastic surgery physician recommendations in the face-to-face evaluation found 79% agreement in skin defect, 76% agreement in bone exposures. Several factors contributed to the significant discordance in triaging of these patients. The authors stated that the remote physicians had difficulty assessing fine details associated with skin edge viability, exposed digital bone, tendon, or nerves and attributed this discordance to use of a camera with only 110,000 pixels, keeping in mind that Bittorf et al. (1997) suggested a minimum of 768 x 512 ( = 393,216 pixels) for digital images. Furthermore, the authors conceded that treatment recommendations for soft tissue injuries will differ among even experienced surgeons and that it is impossible to have absolute concordance in treatment recommendations based on photographic images augmented with verbal communication. Because the reliability of digital images to diagnose and triage soft tissue injuries was based on inexperienced residents, they recommended diagnosis and triage be provided by experienced providers might have elicited higher concordance of agreement.

The reliability of a Panasonic GD88 110,000 pixel mobile camera phone to diagnose and treat lower extremity wounds was also evaluated by Tsai et al. (2004) among patients presenting to the emergency room with a lower extremity wound. Using the mobile camera phone, an on-site emergency room resident took a picture of the wound, saved it to a JPEG file, and transmitted the image to a remotely located plastic surgeon. The patient's medical and surgical history, vital signs, pertinent laboratory findings, and current wound treatment were presented

"on-line" to the remote plastic surgeon. Two other plastic surgeons also reviewed the images. All three plastic surgeons and the emergency room resident completed a questionnaire that evaluated the wound for presence (yes/no) of necrosis, gangrene, erythema, cellulitis/infection, need for antibiotics, or need for surgery.

A total of 60 patients (34 male and 26 female) with lower extremity wounds were enrolled in this study. Inter-rater reliability between the three remote plastic surgeons for each component of the wound assessment was determined by percent agreement and Kappa values. Sensitivity and specificity of the wound assessments between the on-site examination and the remote examination were also analyzed. Erythema had the lowest Kappa value (0.44/moderate) and lowest percent agreement (66%), followed by necrosis with a Kappa value of 0.58 (moderate) and percent agreement (76%), cellulitis/infection Kappa value of 0.61(substantial) and percent agreement (74%), and gangrene Kappa value of 0.73 (substantial) and percent agreement (80%). Gangrene also had the highest sensitivity (85%) and specificity (93%). Erythema had the lower sensitivity (61%) and specificity (76%). Erythema produced the most clinically significant misinterpretation (32%) when compared of that of gangrene (10%), necrosis (20%), and cellulitis/infection (16%). By definition, cellulitis has associated erythema. So, it would be impossible to independently or solely assign erythema and not cellulitis or vice versa to a wound. This provides the rationale for explicit operational definition of terms; otherwise, internal validity of the findings are compromised.

The feasibility of diagnosing and evaluating chronic wounds using the Nokia 7650, equipped with 310,000 pixels, capable of producing a better quality and sharper image was evaluated by Braun et al. (2005). A total of 61 chronic ulcers from 52 patients, including 29 venous, 9 arterial, 7 mixed venous/arterial, 11 diabetic, and 5 atypical ulcers, were visually

inspected by a wound care physician. The 52 participants were randomly recruited from a leg ulcer clinic in Geneva Switzerland. The wound care physician performed the face-to-face exam and two board-certified dermatologists located at a distant location performed a telehealth exam using panoramic and close-up views of the wounds sent to their email accounts.

The wound care physician assessed each wound and rated the percentage of granulation tissue, epithelialization, fibrin, and necrosis in the wound bed. For example, 40% granulation, 20% epithelialization, 30% fibrin, 10% necrosis, for a total of 100%. However, this scale does not take into consideration percentages between 30% to 40%, and 60% to 70%. The periwound was assessed for the presence of erythema, eczema, hyperpigmentation, and cyanosis. If none of these variables were present, the periwound was labeled as "normal".

The inter-rater reliability of wound assessment ratings between the face-to-face exam performed by the wound care physician and the telehealth exams performed by the two remote dermatologists (termed Dermatologist 1 and Dermatologist 2) were analyzed. The overall kappa value for the comparison of ratings between the face-to-face wound care physician and Dermatologist 1 was 0.82 (nearly perfect); Kappa values were highest for epithelialization (0.94, nearly perfect) and lowest for granulation (0.69, substantial). The overall kappa value for the comparison of ratings between the face-to-face physician and Dermatologist 2 was 0.74 (substantial); Kappa values were highest for erythema (0.92) and lowest for necrosis (0.49, moderate). The overall kappa value for the comparison between the two dermatologists was 0.75, which is substantial.

Weak on methodological rigor, Pirris, et al. (2009) crudely evaluated the use of cell phones to assess post-operative surgical wounds in pediatric neurosurgical patients. The three case studies involved the post-operative management of neurosurgical patients with parents

using a cell phone camera to transmit images of their children's surgical sites to the pediatric neurosurgeon. Patients in two of these case studies had myelomeningocele defect closures and complications involving surgical wound dehiscence. The parents transferred images of the surgical sites from their cell phones to the attending surgeon via text messaging or email; the surgeons were able to direct care of the wound remotely. The third patient had a baclofen pump inserted and subsequently fell at home. The mother was concerned about swelling around the incision line. A digital image of the incisional area was taken with the cell phone and sent to the surgeon who was concerned about a cerebrospinal leak. The surgeon brought the patient into the clinic urgently for evaluation; the intrathecal catheter had migrated out of the thecal sac. Although the cell phone pictures were instrumental in providing patient care, as no wound assessment measures were reported for comparison purposes.

Because early detection of vascular compromise in free-flap surgery is crucial, Engel et al. (2011) examined the use of a smartphone to detect early flap compromise. Free flap surgery consists of moving tissue with its blood supply intact from one part of the body to another part of the body to cover a defect or wound. A pedicle flap, a type of free flap, involves rotating tissue to cover a defect or wound while the pedicle remains intact with its own blood supply. With the use of the iPhone 3 smart phone, equipped with a 2-megapixel camera, 1008 photographs were taken of the 103 free flaps involving the head, neck, breast or extremities. The purpose of the study was to explore the inter-rater reliability between remote smartphone photographic assessments and an in-person examination of free flap monitoring to determine the need for surgical re-exploration secondary to a compromised flap, and the response time between the smart-phone group (3 board-certified plastic surgeons) and the in-person group (4 board-certified plastic surgeons).

All photographs in this study were taken using standard settings (no external flash and a standard color card) and at specific time intervals adhering to the standard of care. Beginning on the first post-operative day, a picture was taken in the morning and the afternoon and any time the flap was considered compromised. Photographs were sent via 3G wireless on the smartphone to the three plastic surgeons who then rated the flaps as pink and full (healthy), pale and shrinking skin turgor (arterial insufficiency), or darker color and oozing (venous insufficiency). If photographs were blurred, they were labeled as "un-interpretable". The flap assessment from the cell phone was compared to the actual flap outcome (viable flap/failed flap) to determine the percent correctly classified.

During the study, there were a total of 3024 photographs taken (1008 photographs x three smart-phone physicians). There were two major comparisons: an assessment of the viability of the flap between the in-person assessment and the smartphone assessment, and the determination for the need for surgical re-exploration of the flap. The accuracy of assessments between the in-person assessments was 98.7% and the accuracy of assessments between the smart-phone group was 94.1%. There were 101 photographs that were "un-interpretable". Excluding the "un-interpretable" images increases the accuracy to 97%. There was a high inter-rater reliability between the three smart-phone assessors, 96.1%, 91.1% and 95.1%. All three plastic surgeons provided the same assessment in 94.6% (954/1008). The rate of re-exploration was also similar between the in-person assessment (8.8%) and the smart-phone assessment (8.7%). Response time for re-exploration was shorter for the smartphone assessment. The response time for smart phone assessment was 8 minutes +/- 3 minutes and the response time for in-person assessment was 108 minutes +/- 104 minutes. Consequently, the salvage rate (the percent of re-explorations

that resulted in saved flaps) was significantly higher in the smart-phone group compared to the in-person group, 75% and 40% respectively.

Only one study has evaluated the reliability of cell phone technology for burn care (Shokrollahi et al., 2007). In this study, the Nokia 7610 cell phone with 1 megapixel (1,000,000 pixels) capacity was used to assess 31 patients with a burn size < 10% TBSA. All patients were assessed within 48 hours of the burn injury. The first burn surgeon performed a face-to-face assessment, assigning burn depth (partial and full-thickness) and size (TBSA) and then took a digital image of the burn with the cell phone. The second burn surgeon viewed the image of the burn from that same cell phone and assigned a burn depth and size and then visually inspected the burn face-to-face. The time between the first burn provider's assessment and the second burn provider's assessment was not specified.

The study showed a strong correlation in TBSA between the digital image assessment (which was taken by the first burn surgeon) and the first burn provider's assessment of the TBSA ($r = .91$), and the second burn surgeon's assessment of the digital image compared to a face-to-face assessment ($r = .92$). However, correlating the second surgeon's assessment from a digital image to his assessment from a face-to-face exam introduced some memory (recall) bias. Providers were also able to differentiate between partial-thickness and full-thickness burns in 94% of the cases.

**Summary of Digital Imaging Using Cell-Phone Camera**

The previous studies clearly demonstrate the use of store-and-forward technology through camera cell phones for burn and wound assessment. Every few years, a newer model digital camera and newer generation camera cell phone was introduced, capable of producing higher quality digital images. Camera cell phone with only 110,000 pixels (Hseih et al., 2004)

inferred some concerns regarding patient safety and potential medicolegal concerns with implementing telehealth technology in the management of soft tissue injuries. As camera cell phones became equipped with 310,000 pixels (Braun et al., 2005), then 1 megapixel (Shokrollahi, et al., 2008), then 2 megapixels (Engel), reassurance about the reliability of mobile telehealth technology use improved. The enhanced digital imaging of cell phone cameras likely influenced the reliability of most of these studies and will continue to impact the future direction of telehealth but the cell phone screen size is smaller than the size of a tablet screen The following section provides an overview of telehealth applications specific to burn care, utilizing mostly store-and-forward technology but a few studies implementing a combination of interactive video consultations, supplemented with digital images and email.

**Telehealth and Burn Care**

Some studies have examined the use of telehealth to improve patient access to burn care. Synchronous and asynchronous methods have been employed in these studies to help distant, inexperienced providers collaborate with a burn specialist to effectively manage burn patients. The following research examines telehealth strategies and its impact on burn patient triage, recommendation for surgery, length of stay, travel time and associated costs, and outpatient follow-up care.

**Facilitate Triage and Appropriate Transfer**

Between 2000-2010, there were four studies that evaluated in-patient management of burn patients using either store-and-forward or interactive telehealth technology (Saffle et al., 2009; Sagraves, et al., 2007; Turk, et al., 2010; Wallace, et al., 2008). When evaluating the level of evidence of this research, only one study was a cohort study (Wallace, et al., 2008); the other studies used a descriptive design. How telehealth improves a burn patient's access to care

through facilitation of triage and appropriate transfer of care is examined in the following studies and outlined in Table 3.

To improve access to care for rural eastern North Carolina burn patients, specialists from a regional burn center collaborated with a rural trauma center (RTC) hospital to assess the feasibility of providing outpatient burn care at the RTC using telehealth technology (Sagraves, et al., 2007). An outpatient burn clinic was implemented and operated within the RTC hospital two days a week. Seven trauma and critical care surgeons all trained in burn care and one trauma clinical nurse specialist with some training in burn care staffed this clinic. The decision to transfer a patient from the RTC hospital or outpatient burn clinic to the regional burn center was made by the rural trauma surgeon and contingent on the extent and type of burn, patient co-morbidities, and availability of in-patient resources. A dedicated phone line and communication through email with digital images allowed the rural providers to collaborate 24/7 with the regional burn center staff.

A retrospective analysis of January 2000 to June 2005 data showed that 178 burn patients presented to the RTC hospital. Nearly half of these patients (47%) were transferred to the regional burn center for definitive burn care. The remaining 53% remained at the RTC hospital for continued in-patient burn care. Furthermore, the RTC's outpatient burn clinic treated 311 burn patients with a mean (3%) total body surface area burned. The majority of the burns were partial-thickness (95%), a little over 1% of the burns were first-degree and 3% of burns were full-thickness. On average, the burn wounds healed in 6 weeks. However, partial thickness burns generally heal in 2-3 weeks (Hartford & Kealey, 2007). There were 31 (<10%) burn-related complications; ten patients (3%) developed a local burn cellulitis and 13.4% of patients developed hypertrophic scarring.

Table 3
*Studies Evaluating Telehealth in Triage of Burn Patients*

| Authors | Year | Sample Size | Purpose | Design | Technology | Variables | Statistics | Findings |
|---|---|---|---|---|---|---|---|---|
| Sagraves, Bard, Toschog, & Peck | 2007 | 178 | To assess the feasibility of providing outpatient burn care in a rural trauma center collaborating with regional burn center | Retrospective, feasibility | S-F and email and 24-hour dedicated phone line | Number of transfers to the regional burn center, wound care complications | Descriptive | Over 50% of patients presented to RTC were treated at RTC. Les than 10% burn related complications |
| Wallace, Jones, Milroy, & Pickford | 2008 | 389 | Compared medical management of burn and plastic surgery patients using S-F vs telephone consultations | 12-week prospective cohort | S-F sent via email, 1600 x 1200 | Number of patient admissions, need for FTF assessment, number of patients scheduled for same-day surgery | Chi-square | Increase in number of telehealth consultations, more patients directed toward same-day outpatient sugery compared to direct admission and next day surgery |

*S-F = Store and Forward
FTF = Face-to-Face
RTC = Rural Trauma Center

Table 3 continued

| Authors | Year | Sample Size | Purpose | Design | Technology | Variables | Statistics | Findings |
|---|---|---|---|---|---|---|---|---|
| Saffle, Edelman, Theur, Morris, & Cochran | 2009 | Pretelehealth 29; Telehealth 70 | Assessed the feasibility of evaluating acute burn patients | Retrospective descriptive comparing patients in the pretelehealth era (2003-2005) to the telehealth era (2005-2007) | ITV | Patient demographics, burn size, transportation (air vs ground), and outcomes (number of surgeries, LOS, costs) | Non parametric t-tests | All patients in the pretelehealth era were transported by air compared t 31/70 (44.3%) in the telehealth group. Burn estimates were statisticaly different ($p<.05$) between rural, telehealth, and face to face, with telehealth and face to face correlating closely. Pretelehealth patients required more surgeries |
| Turk, Karagulle, Aydogan, Oguz, Tarim, et al. | 2010 | 187 telehealth patients and 525 telehealth visits | Evaluated telehealth for decision-making and f/u of burn patients | Descriptive analysis of 187 telehealth consultations | ITV, S-F, and telephone | Age, gender, burn size, mechanism of burn injury, LOS, mortality, number of telehealth consultations, number of patients transferred | Descriptive statistics | Decreased nmber of patients transferred to the main burn center, mortality decreased over time, decreased number of telehealth consultations due to an increase in experience in remote providers |

*ITV = Two-way Interactive Televideo
LOS = Length of Stay

Although there were some untoward burn-related outcomes, a "collaborative systems approach" did reduce the amount of travel time experienced by burn patients living in rural areas. For this particular study, residents would have traveled 2-4 hours by car to reach the regional burn center. Cost comparisons were not computed.

Telehealth's potential for improving triage and management of burn and plastic surgery patients was further assessed at Queen Victoria Hospital (QVH), England in a study that compared the medical management of burn and plastic surgery patients using store and forward telehealth versus usual telephone consultation for triage (Wallace et al., 2008). The telehealth system (software for data acquisition, storage, and retrieval) was installed in 10 of the 60 outlying hospitals who had referred the most patients to QVH. The first phase of the study was a 10-week retrospective analysis of the telehealth system and education of the 10 referring centers. Although there was an initial resistance of referring physicians to use the system, telehealth was implemented in 42% of the 452 patient referrals. Referring physicians eventually found the system easy to use and the receiving physicians found improved clarity of patient information.

The second phase involved a 12-week prospective cohort comparing patient management using telehealth to patient management using the usual method of telephone conversation for triage. Patient management between the two groups were compared on the following variables: the number of patient admissions, need for a face-to-face assessment for review, need for a dressing clinic, number of patients scheduled for day surgery, number of patients the regional hospital was unable to accept because the burn unit was at full capacity, the number of patients evaluated as an outpatient outlier, telephone advice, and inappropriate referral. In addition, digital images taken by the referring physician were sent via encrypted email to the telehealth team (nurses, plastic and maxillofacial surgeons, and IT specialists from QVH).

The results from the 12-week prospective cohort demonstrated a significant difference ($p = 0.004$) in the management of patients using telehealth and the management of patients through telephone consultation. Specifically, there were 996 referrals to QVH; 607 were referred through telephone consultation. Of the 389 referrals that came from hospitals with telehealth services, 243 (62%) used telehealth, a 20% increase from the initial 10-week analysis. Among the 996 referrals, 150 were burn referrals, with equal numbers of patients being triaged from the telehealth and telephone consultation. More burn referral patients evaluated by telehealth were directed toward "same day" outpatient surgery (27.5%) compared to the telephone group (17%), resulting in fewer hospital admission and decreased associated hospital costs. Medical decision-making formulated from a digital image compared to a telephone consultation likely resulted in fewer patients needing to return to the hospital for reassessment (15.4% in the telehealth group compared to 22% in the telephone group). The authors did not provide a conceptual or operational definition of variables, thereby compromising construct validity.

Attesting that burn wound assessments from inexperienced rural physicians contributes to under or over-triage of burn center referrals and unnecessary air transportation, Saffle et al. (2009) assessed the feasibility of evaluating acute burn patients located at rural emergency rooms using telehealth technology. The University of Utah Burn Center, Salt Lake City served as the telehealth hub, providing burn expertise to three rural hospitals located 250-350 miles away (Boise, Idaho; Billings, Montana; and Helena, Montana). Each rural hospital emergency room was equipped with a portable Polycom VSX 7000 televideo cart, containing a video and hand-held camera linked to a dedicated internet connection. The telehealth implementation occurred from 2005-2007 (telehealth group) and was compared to the previous two years (2003-2005)

when telehealth had not yet been employed (pre-telehealth group). Data points included patient demographics, burn size, transportation (ground versus air), and outcomes (number of patients requiring surgery, length of stay/LOS, and hospital charges). Estimates of burn size were obtained from the referring physician, telehealth physician and the receiving (face-to-face) burn unit physician.

From 2003-2005, there were 29 patients who were referred to the University of Utah Burn Center by the three participating rural hospitals. All 29 patients were transported by air to this burn center. Between 2005-2007, there were 70 patients who were referred to the University of Utah Burn Center. Of these, 31 (44.3%, $p < 0.05$) were transported by air, and 9 patients were transported by ground (private vehicle). The remaining 30 patients were considered appropriate to be treated at the rural hospital.

Burn size is one of the ABA's criteria for burn center referral and influences mode of transportation to a burn center (air, ground/ambulance, or ground/private vehicle) (Saffle et al., 2004). The TBSA for the pre-telehealth group ranged from 0% to 85% (median 6.5% TBSA). The TBSA for the telehealth group ranged from 0.5% to 30.5% TBSA. It was difficult to determine if the size of the burn influenced which mode of transportation was recommended. Telehealth patients transported by air had a TBSA of 2% to 30.5%. Patients transported by ground had a TBSA of 0.5% to 6.5% TBSA, and patients treated at the rural hospital had a TBSA range from 0% to 12% TBSA.

For the telehealth group, analysis of variance showed the estimates of TBSA burned were statistically different ($p < 0.05$) between the three providers (referring/rural physician, telehealth physician, and face-to-face burn physician). Average burn size estimates for the referring/rural

physician were 11% TBSA; Average burn size estimates for the telehealth physicians were 7.0 % TBS), and the average burn size estimates for the face-to-face burn physician were 7.3% TBSA.

There were also differences in the length of stay and the number of patients who required surgery between the pre-telehealth and the telehealth groups. In the pre-telehealth group, patients had a shorter length of stay (8 days compared to 13 days for patients in the telehealth group who were transported by air). LOS for those patients treated at the rural hospital was not provided. The prolonged LOS could be attributed to larger TBSA. For patients requiring surgery, the pre-telehealth patients required more surgeries. In the pre-telehealth group, 15 of the 29 patients (54%) required surgery in contrast to 14 of the 31 patients (46%) in the telehealth transported by air group, and 4 of the 9 patients (44%) in the telehealth transported by ground group. Saffle et al. successfully demonstrated how telehealth facilitated clinical decision-making and expanded access to care over a large geographic area.

In an effort to decrease expensive and complicated burn transfers, Baskent University (Turkey) evaluated a telehealth system in the management of burn patients (Turk, et al., 2011). Baskent University is comprised of three regional hospitals, Ankara, Adana, and Konya. From 1997-2009, there were 1560 burn patients admitted to the three Baskent University Hospitals. Baskent University-Ankara has over 40 years' experience in burn care and therefore functions as an "expert" burn center. Established in 2003, the Konya Burn Unit is staffed with less experienced burn personnel. To assist health care providers with limited experience in burn care, Ankara and Konya established a telehealth network utilizing inter-active video, store-and-forward technology, and telephone consultations. All patients admitted to Konya from 2003 to 2009 had a telehealth consultation with the burn expert from Ankara. To evaluate their system for decision-making in treating burn patients, a retrospective analysis of the data included

demographic information (gender, age, TBSA, mechanism of burn injury), the number of burn patients admitted, number of telehealth visits, number of patient deaths, and the number of patients referred to Ankara's Burn Unit.

Over 66 months, there were 187 patients admitted to Konya's Burn Unit and 525 telehealth consultations performed. Then, according to the Ankara burn surgeon's expert advice, the patient either remained at the Konya Burn Unit or was transferred to Ankara for definitive care. Of the 187 patients, 21 patients (11%) required transfer to Ankara. One hundred and fifty seven patients (84%) were successfully discharged while nine died due to multi-organ failure. Over time, the mortality rate and the number of telehealth consultations from Konya and the number of patients transferred to Ankara from Konya decreased, while the number of patients admitted each year to Konya increased. This suggests an increase in "rural" physician expertise leading to appropriate and timely transfer of patients to Ankara, thereby contributing to the decrease in burn mortality.

**Outpatient Burn Care**

When a patient is discharged from an in-patient burn unit or never meets admission criteria, then outpatient management of burn patients typically occurs in an affiliated outpatient burn clinic. In the outpatient setting, burn care is provided to patients through weekly visits until the burn wound has healed and then monthly until the burn scar is stable, followed thereafter every three months until the scar has reached maturity. In general, the duration of follow-up care is dependent on the severity of the burn injury. The outpatient management of follow-up burn care reduces patient travel time, travel related costs, and facilitates accurate burn assessment of healing. A recent review of the literature revealed three studies that used telehealth in the

outpatient management of burn patients (Table 4) (Nguyen, et al., 2004; Smith, Youngberry, Mill, Kimble, & Wootton, 2004; Smith, Kimble, et al., 2004).

Burn specialists at the Royal Children's Hospital (RCH) in Brisbane Australia evaluated the feasibility of delivering outpatient telehealth burn services for children residing in rural and remote areas of the state (Smith, Youngberry, et al., 2004). In an effort to save patient and family time and costs associated with traveling long distances to the burn center, the RCH collaborated with general practitioners located at 31 regional hospitals throughout Queensland and South Wales to deliver outpatient burn management to patients residing 100 km to 3000 km away. After a period of 3 years, a retrospective analysis was performed examining their experience.

During the 3 year period, there were 293 telehealth consultations. All of the telehealth consultations included real-time video-conferencing (average bandwidth of 128kbit/s), with 17 (6%) incorporating still digital images sent via email to assist with diagnosis or management. Initially, the telehealth consultations occurred on an as needed basis. However, the frequency of telehealth consultations grew necessitating scheduled telehealth clinics. By the end of the study, the RCH had developed monthly scheduled telehealth clinics, evaluating 4 patients per clinic, increasing their pediatric telehealth services from 55 in 2000 to 145 in 2003.

In a follow-up study, Smith, Kimble, et al. (2004) explored the accuracy of telehealth services through video-conferencing to provide outpatient management of pediatric burns. The burns of pediatric patients were assessed in-person and through videoconferencing by two different burn specialists within a one hour period.

Twenty-five children received three consecutive assessments. The first assessment was an in-person assessment by one burn specialist that occurred in the burn clinic.

Table 4
*Studies Evaluating Telehealth in Outpatient Management of Burn Patients*

| Authors | Year | Sample Size | Purpose | Design | Technology | Variables | Statistics | Findings |
|---|---|---|---|---|---|---|---|---|
| Smith, Youngberry, Mill, Kimble, & Wooten | 2004 | 293 | To analyze telehealth to deliver outpatient pediatric burn services | Retrospective Cohort | ITV, digital mages | Number of telehealth consultations over a 3 year period | Descriptive | All consultations used ITV, with 17 (6%) using digital images to augment clinical decision-making |
| Smith, Kimble, Mill, Bailey, O'Rourke, et al. | 2004 | 25 | To compare agreement between clinical assessments made via ITV and FTF | Cohort, retrospective | ITV | Scar assessment: color, thickening, contractures, ROM, graft breakdown | Percent Agreement | High concordance between providers and between modalities on contracture, ROM, graft-breakdown |
| Nguyen, Massman, Franzen, Ahrenholz, Sorenson, et al. | 2004 | 294 | Evaluated 1000 telehealth visits in burn care for travel costs and financial data | Retrospective | ITV, digital images | Provider costs per telehealth visit and travel expense | None | Decrease in costs associated with telehealth visit , travel costs |

*ITV = Two-way interactive televideo;
ROM = Range of Motion

Then, the patient was examined through video-conferencing by a second burn specialist. The second burn specialist then went into the patient's room and assessed the burn in-person. Scar appearance (pale, pink, or red), scar thickening (yes/no), and scar contracture (yes/no), range of motion (restricted/unrestricted), activity level (restricted/unrestricted), and graft breakdown (yes/no) were measured at each assessment. Another 10 patients were assessed by one of the burn specialists who alternated the order of the two modalities used. The same wound components were assessed

Three comparisons were completed. In comparison 1, the overall concordance in agreement between the two burn specialists for in-person and video-conference assessments was 84%. The lowest concordance in agreement was 60% for scar appearance and scar thickening. Scar contracture, range of motion, and graft breakdown shared the highest concordance, at 92%, 92%, and 96%, respectively.

In comparison 2, the overall agreement between the two burn specialists when assessing patients in-person was high, 85%. There was minimal difference in concordance of agreement in scar appearance (68%), scar thickening (60%), contracture (92%), range of motion (92%), and graft breakdown (96%). The overall agreement between the two burn specialists when assessing patients in-person was high, 85%.

In comparison 3, the order of the modality used was evaluated. If a provider examined a patient in-person and then through video-conferencing, there was 100% concordance in assessment of scar thickening, scar contracture, range of motion, and graft breakdown, and 90% concordance of scar appearance. If the provider examined the patient using video-conferencing and then in-person, agreement of the appearance in scar diminished slightly to 88% and scar thickening decreased slightly to 96%. Findings suggest more memory (recall) bias exists when

the initial assessment is a face-to-face assessment (standard care), followed by a telehealth assessment (video-conference) compared to an initial assessment that is performed through telehealth (video-conference), followed by a face-to-face examination.

From 1997-2003, Regions Burn Center, in St. Paul, Minnesota, completed a total of 1000 telehealth visits to follow 294 patients with burns (Nguyen et al., 2004). There were 72 telehealth sites (where patients are treated) in six states, Iowa (5), Minnesota (28), Montana (3), North Dakota (20), South Dakota (5), and Wisconsin (11). Of the 1000 telehealth visits, most were follow-up visits from patients discharged from Regions Burn Center and having their outpatient burn care provided via telehealth. Twelve visits were initial consultations where the patient had not been previously seen at the Regions Burn Center. Travel costs and financial data were evaluated. Demographic and financial data, as well as financials on purchased telehealth equipment were also recorded. This study implemented both interactive video-conferencing as well as digital imaging using store and forward technology. The authors state the following variables were measured, however, do not report on the findings: pain control, sleep quality, psychological well-being, healing, ROM, physical well-being, ability to return to work/school, OT/PT, home-care needs, evaluation of compression garment fit, and hypertrophic scar maturity. A burn surgeon was involved in 98% of the visits, a burn therapist was involved in 66%, and a clinical psychologist met with approximately 4% of the patients. Telehealth charges were assigned based on the provider (burn surgeon, burn therapist, and clinical psychologist), the facility fee (based on the number of minutes, 15 to 60 minutes). The authors report the total telehealth costs for 1000 visits were $145,522, with the average cost per telehealth visit of $146 dollars. However, due to underdeveloped reimbursement mechanisms, a significant portion of these charges are lost. The authors reported additional cost savings to the patient in reduced

travel expenses. Using the 2000 Internal Revenue Service Standards for mileage costs, the average cost for the patient to travel to a face-to-face visit was $166 per visit compared to telehealth travel cost of $20, equating to a $146 savings (Nguyen et al., 2004).

**Summary of Telehealth in the Outpatient Management of Burns**

Few studies have implemented telehealth technology in the outpatient management of burn patients. Several studies have established telehealth as a reliable instrument to accurately diagnose burn depth and facilitate accurate triage and timely transfer of burn patients to a burn center. However, only three studies examined the use of telehealth in outpatient burn management. Of these three, one analyzed the telehealth utilization (Smith, Youngberry et al., 2004), one compared the accuracy of a telehealth assessment compared to a face-to-face assessment but most of the variables related to scar management and did not include acute outpatient burn care from initial burn care to scar maturation (Smith, Kimble et al., 2004). The third study mostly examined telehealth utilization and associated costs.

**Patient Perception with Tablet Use**

One of the tenets of the Behavioral Model of Health Services Use states that **"**effective access is established when utilization studies show that use improves consumer satisfaction" (Andersen, 1995, p. 6). Definitions of patient satisfaction vary but some define patient satisfaction as the user's perception of the care experience (Bear & Bowers, 1998, p 50). Thus, beyond establishing the feasibility of using a tablet device in burn assessment, an examination of patients' perception of tablet use is essential to gaining insight on the comfort or discomfort with future tablet use.

A literature review revealed few studies describing patients' perception of tablet use, likely because tablet use in telehealth is new (Vawdry, Wilcox, Collins, Bakken, Feiner, Boyer,

& Restaino, 2012; Wofford, Campos, Johnson, & Brown, 2012). In a study performed at Columbia University Medical Center, researchers explored the use of the iPAD® for patients to use during their hospital stay to actively participate in their hospital care (Vawdry, et al., 2012). The pilot study included 5 patients in a cardiac step-down unit, who used the tablet to review prescribed medications, and nursing and medical staff caring for them. They conducted detailed semi-structured interviews to assess the patient's knowledge of their in-patient care and their perceptions of the usefulness of the application. Interviews revealed several themes regarding satisfaction, comfort, and ease of use with the tablet device. Although 4 out of the 5 patients had never used a tablet device before, most felt use of the tablet device would improve patient satisfaction with their care and increase one's sense of engagement in their care. Suggestions for enhanced functionality included improving the size and layout of the icons.

In a related iPAD® study, the use of a tablet device to deliver outpatient interpreter services in a busy medical clinic was examined (Wofford, Campos, Johnson, & Brown, 2012). The overall quality of the interpretation services through a tablet device, hearing and visual quality, time spent per visit, and potential for future use were evaluated. Most patients (24/25) and clinicians (17/18) rated the overall quality of the tablet device as excellent and the technical audio/visual quality as excellent or good. There was useful information gathered regarding tablet device positioning. Post-encounter debriefing revealed that positioning of the computer in the examination room was important enough that orientation of the patient and clinician before the encounter was necessary. Also, a special swiveling computer stand was necessary for visualization. Patients needed reassurance that, even though the network and software were encrypted, unintended others were not seeing or hearing the video.

## Conclusion

The reliability of assessing burn depth from a digital image (digital camera or cell phone) has been established. However, current review of the literature is devoid of research evaluating tablet technology for delivering real-time, synchronous burn management. Furthermore, there is a scarcity of research evaluating telehealth in facilitating burn triage and comprehensive outpatient burn care in the United States.

Historically, two-way interactive telehealth required specialized and expensive equipment at both the tertiary facility and the distant facility. However, the next wave of technology, a tablet device, offers the functionality of real-time two-way video-conferencing at a fraction of the cost. On an internet blog on the use of tablet devices in healthcare, hospitals are beginning to embrace the tablet device as a means of improving collaboration between providers (http://www.healthcareitnews.com/blog/usage-tablets-healthcare-industry?page=1). Future research needs to establish the reliability of providing patient care efficiently and accurately through the use of a tablet device.

# CHAPTER III METHODOLOGY

This feasibility study aimed to evaluate the reliability of a tablet device for outpatient burn assessment and describe participant perceptions with use of the tablet device. Review of the literature revealed a scarcity of research evaluating telehealth in the outpatient management of burn care. Furthermore, at this time, no published studies were found describing the use of a tablet device for in-patient or outpatient burn care management. Using a tablet device to assess burn injuries provides the foundation to support telehealth as a viable, authentic, alternate mode of health care delivery and potentially improve access to care. In this chapter, the research design, study setting, and sample are described. The variables are defined and operationalized. Data collection procedures and statistical analysis for each research question are detailed.

## Research Design

The design of this study is a mixed method embedded design. In this design, the researcher collected and analyzed both quantitative and qualitative data within a traditional quantitative or qualitative design. The mixed-method embedded design is useful when a single data set does not adequately address the study's purpose and requires a separate type of data to answer the research questions (Creswell, 2006).

The researcher must decide at what point to collect the quantitative and qualitative data. In this study, the primary purpose was to evaluate the reliability of using a tablet device to perform a standard burn assessment relative to the usual face-to-face examination (quantitative data). After the quantitative data were collected, participants' perceptions about using a tablet device were elicited through patient interviews.

## Setting and Sample

### Setting

The Outpatient Burn and Wound Care Center (OBWCC) is affiliated with the Burnett Burn Center, an ABA verified burn unit. Operating for over four decades, the OBWCC treats patients with new burn injuries who have been seen initially at the KU Emergency Department or surrounding area emergency departments, as well as referrals from surrounding primary care facilities, urgent care centers, businesses, or self-referrals. In addition, the OBWCC also treats burn patients who have been hospitalized and require continued outpatient burn care. On average, the OBWCC treats approximately 300-350 patient visits per month, averaging 25-30 new burn patients per month.

The OBWCC is staffed by one nurse practitioner, a physician's assistant, two burn plastic surgeons, three burn nurses and a burn technologist. The primary nurse practitioner is a Certified Wound Specialist, with 7 years of full-time burn experience and over a decade of wound experience who also served as this study's nurse researcher. The physician's assistant has less than one year of experience and was not a part of this study. Two of the burn nurses each have about twenty years of burn nursing experience and are Wound Care Certified; the third burn nurse has seven years of burn nursing experience and is also Wound Care Certified. The burn technologist has 38 years of burn experience. The senior burn plastic surgeon is head of the Department of Plastic Surgery with over two decades of burn experience. The second burn surgeon is the Director of the Burnett Burn Unit and OBWCC and has over ten years of burn experience.

**A priori Power Analysis for Sample Size**

Using the goodness-of-fit formula provided by Donner and Eliasziw (1992), the number of subjects required in a reliability study comparing two ratings to detect a statistically significant kappa of 0.80 ($p \leq .05$) on a dichotomous variable with 80% power, with a proportion of positive ratings of 0.5, is 48 subjects, assuming the null hypothesis value of kappa is 0.40.

**Sample**

A convenience sample of 50 subjects was recruited from the University of Kansas Hospital Outpatient Burn and Wound Care Center (OBWCC). Subjects recruited for the study included patients with a new burn injury from any etiology (scald, flame, thermal, grease, electrical, or chemical) who initially presented to the OBWCC for burn care (referred from an outside facility or provider) or patients recently discharged from the University of Kansas Hospital in-patient burn unit with either an open burn wound or recent skin graft. Participants could take part in the study regardless of socioeconomic status or ethnic background.

Other subject inclusion criteria for this study were:

- ≥ 18 years
- English-speaking
- ICD-9 burn diagnosis of 940-949.5 (partial and/or full-thickness burn injury), covering less than 10% TBSA (initial burn size) on any location of the body. Over 90% of the patient's evaluated in the KU OBWCC have less than 10% TBSA burned.

Excluded from the study were patients with > 10% TBSA (initial burn size). According to ABA burn admission criteria, patients with >10% TBSA should be considered for admission to a verified burn center. Patients with TBSA <10% can be treated in an outpatient setting. Also

excluded from the study were patients who were unable to participate in multiple telehealth and face-to-face examinations because of burn-related discomfort.

Based on the availability of KU OBWCC staff, recruitment of 50 subjects could be accomplished over a period of 4-5 months. A weekly enrollment of no less than 3 patients per week was anticipated.

**Sample Recruitment Procedures**

Patients were recruited for the study using the following methods. Patients with a new burn injury were called the day before the first scheduled clinic visit (the patient would have already confirmed their appointment) by the OBWCC receptionist and "introduced" to the study using a scripted format (Appendix D). Contact information for the OBWCC nurse practitioner/study nurse researcher was provided for patients who had questions about the study before the first clinic visit. For those patients not able to be reached prior to the first clinic visit and walk-in patients, initial study information was provided at the first clinic visit.

At the first clinic visit, the OBWCC receptionist provided each new burn patient with written study information about the study as he/she signed in for the appointment (Appendix E). The patient indicated his/her interest in learning more about the study/participating in the study on the written study information sheet. Patients were escorted from the OBWCC waiting area by the burn technologist and brought back to an examination room with dressing intact. The technologist gave the study nurse researcher the study information sheet that identified patients who were interested in hearing more about the study and the patient exam room location. Patients received their usual care from clinic staff using standard processes. Those patients who indicated an interest in the study and met study inclusion criteria were approached by the study nurse researcher and provided additional information regarding the study as well as an

opportunity for the patient/family members to ask questions. Patients who agreed to participate in the study signed consent in the examination room.

## Study Measures

### Demographic Measures

Typically, demographic information is recorded in the patient's electronic health record (EHR). The OBWCC receptionist enters the patient name, home address, date of birth, and gender into the EHR. The health care providers (nurse practitioner, burn plastic surgeons) are responsible for entering the remainder of the demographic variables into the patient's EHR.

Demographic variables for this study included: age, gender, ethnicity, race, date of injury (DOI), mechanism of injury (MOI), location of burn injury (neck-anterior/posterior, upper extremity-left/right, hand-left/right, chest, abdomen, upper back-left/right, shoulder-left/right, lower back-left/right, thigh-left/right, lower leg- left/right, and foot-left/right), total body surface area (<1%, 1%, 2%, 3%, 4%, 5%, 6%, 7%, 8%, 9%, 10%), and distance from home to the clinic (in miles). For patients who consented to be in the study, the aforementioned demographic variables were also recorded on a separate demographic information sheet (Appendix A).

### Standard Burn Assessment Measures

The Standard Burn Assessment included the measurements of burn depth, purulent drainage (exudate), periwound rash, presence of cellulitis, edema, and if grafted (split-thickness skin graft), percent graft take. The ABA (2009) categorizes burn depth as superficial partial thickness, deep-partial thickness, or full-thickness burn. A superficial partial thickness burn will typically have a blister, separating the epidermis from the dermis. It may take 12-24 hours for a blister to occur. Once the blister has been debrided, a superficial partial thickness burn will have minimal damage to the dermis, with a pink, red and moist wound bed, and brisk capillary refill.

Superficial partial thickness burns are typically painful because the nerve endings have not been damaged and remain intact (Johnson & Richard, 2003; ABA, 2009). Deep-partial thickness burns result in damage to the deeper layers of the dermis with loss of some hair appendages, and a mixed red and waxy white wound bed. Capillary refill may be present but sluggish. Deep partial thickness burns are generally less painful (Johnson & Richard, 2003; ABA, 2009). A full thickness burn has complete loss of the epidermis, dermis and extends to the subcutaneous tissue, with loss of hair appendages, and a pale and white leathery wound bed (Johnson & Richard, 2003; ABA, 2009). Full-thickness burns require excision and grafting. Depth is not assessed once a burn has been grafted. The burn wound was also assessed for presence of purulent exudate (yes/no).

The periwound is the skin around the burn wound and was assessed for the presence of a rash (yes/no). Cellulitis, a soft-tissue infection with localized erythema, heat, tenderness, pain and edema (Pruitt, McManus, Kim & Goodwin, 1998), was operationalized as present (yes/no). Edema, defined as observed swelling of the tissue surrounding the burn wound area was operationalized as present (yes/no). If the wound has been grafted, graft take (yes/no) is defined as 90% or greater split-thickness graft adherence.

These measures and their response options are detailed in Table 5. For patients who consented to participate in the study, the Standard Burn Assessment was performed through tablet use and in face-to-face encounter and recorded on the Standard Burn Assessment Data Collection Form. (Appendix B)

**Feasibility of Standard Burn Assessment**

In addition to the Standard Burn Assessment measurements, the feasibility of using a tablet device to adequately visualize each component of the Standard Burn Assessment was evaluated. A rater's ability to adequately visualize each component of the Standard Burn Assessment (burn depth, drainage, rash, cellulitis, edema and if grafted, graft take) was completed for the tablet device assessments only. Feasibility was measured by the rater's opinion about the ability to adequately visualize and assess each component of the Standard Burn Assessment for diagnosis and clinical decision-making. If the rater identified that visualization of a specific component of the Standard Burn Assessment was not adequate to visualize, then the rater was asked to provide a comment about the visual limitation or inadequacy.

Feasibility was operationalized as adequate visualization of burn depth for assessment and clinical decision-making (yes/no, or not applicable [NA] if burn depth cannot be visualized due to skin grafting), adequate visualization of burn drainage for assessment and clinical decision-making (yes/no), adequate visualization of periwound rash for assessment and clinical decision-making (yes/no), adequate visualization of cellulitis for assessment and clinical decision-making (yes/no), adequate visualization of edema for assessment and clinical decision-making (yes/no), and adequate visualization of graft take for assessment and clinical decision-making (yes/no, or NA if the burn has not been grafted). These measures and their response options are detailed in Table 5.

Table 5
*Standard Burn Assessment and Feasibility*

| OUTCOME VARIABLES | OPERATIONAL DEFINITION | LEVEL OF MEASUREMENT |
|---|---|---|
| **Burn Depth** | | **Categorical/Nominal**: |
| Superficial Partial thickness | Epidermis lost, minimal damage to dermis, red/wet bed, blisters | Superficial Partial Thickness (1) |
| Deep-Partial | Pale pink wound bed, deeper damage to dermis, loss of some appendages | Deep-Partial (2) |
| Full thickness | Complete loss of epidermis, dermis and appendages, pale/leathery bed | Full thickness (3) |
| | | NA=skin graft (99)<br>Only select NA if the burn has been grafted |
| **Burn Depth: Adequate Visualization for Assessment and Clinical Decision-Making**<br><br>**If no, Comment:** | | Yes (1)<br>No (0)<br>NA=skin graft (99)<br>Only select NA if the burn has been grafted* |
| **Purulent Drainage** | | **Categorical/Nominal:** |
| | Yellow, tan, or green wound fluid/exudate present on the wound bed and wound dressing | Yes (1)<br>No (0) |
| **Purulent Drainage: Adequate Visualization for Assessment and Clinical Decision-Making**<br><br>**If no, Comment:** | | Yes (1)<br>No (0) |
| **Periwound Rash** | | **Categorical/Nominal:** |
| | Erythematous papules, pustules, milia, or excoriated/denuded skin around the burn wound | Yes (1)<br>No (0) |
| **Periwound Rash: Adequate Visualization for Assessment and Clinical Decision-Making**<br><br>**If no, Comment:** | | Yes (1)<br>No (0) |

Table 5 continued

| OUTCOME VARIABLES | OPERATIONAL DEFINITION | LEVEL OF MEASUREMENT | |
|---|---|---|---|
| **Presence of Cellulitis** | | **Categorical/Nominal:** | |
| | Erythema, warmth, localized pain, tenderness, edema of the skin around the burn wound | Yes<br>No | (1)<br>(0) |
| **Presence of Cellulitis: Adequate Visualization for Assessment and Clinical Decision-Making** | | Yes<br>No | (1)<br>(0) |
| **If no, Comment:** | | | |
| **Presence of Edema** | | **Categorical/Nominal:** | |
| | Increased interstitial fluid in the tissues of the affected burn area, observed swelling of the tissue surrounding the burn wound area | Yes<br>No | (1)<br>(0) |
| **Presence of Edema: Adequate Visualization for Assessment and Clinical Decision-Making** | | Yes<br>No | (1)<br>(0) |
| **If no, Comment:** | | | |
| **Skin Graft Take** | | **Categorical/Nominal:** | |
| | Greater than 90% graft adherence | Yes<br>No<br>NA (no graft) | (1)<br>(0)<br>(99) |
| **Skin Graft Take: Adequate Visualization for Assessment and Clinical Decision-Making** | | Yes<br>No<br>NA (no graft) | (1)<br>(0)<br>(99) |
| **If no, Comment:** | | | |

**Tablet Device**

The Motorola XOOM tablet personal computer (PC) equipped with video camera was used in this research study. The Motorola XOOM is a highly-rated tablet PC and features an Android 3.1 Honeycomb operating system developed by Google. The XOOM tablet has twice the memory and battery life of those on the market. The tablet has 32GB of memory, camera auto-focus and a 10 hour battery for extended use. Additionally, the 10.1 inch display is one of the largest on the market and the 2 megapixel webcam provides large, clear, high resolution (1280 x 800 pixels) images for patients' and health professionals' two-way interactions. Moreover, the XOOM tablet applications can be generalized to similar tablets on the market and was readily available for use in this study.

For this study, XOOM tablets were equipped with the Polycom Real Presence Mobile (M100) videoconferencing software. This simple software allows patients to engage in a live, interactive videoconference with their burn care providers. This software allows either point-to-point or multipoint videoconference capability with other tablets, smartphones, desktop computers or room-based videoconference systems. The tablet devices communicate or "meet" over the Polycom RMX 4000, the KUMC bridge network. The providers were assigned a dial-in number that holds a conference port on the bridge for the tablet devices to connect. The M100 has HIPAA approved encryption when used on the KUMC bridge system. There is no cost to use the KUMC bridge for connecting multidisciplinary professionals within the University of Kansas Hospital system.

There were two XOOM tablets, one for assessments of study patients in an examination room and one for the providers. Movement of the tablet device, if hand held, can distort video-image. To minimize this movement during the assessment of study patients, the XOOM tablet

was placed on a portable, adjustable, clinic approved stability device (the Telescopic Mobile Rack). The XOOM tablet and stability device was cleaned between patient encounters per clinic protocol and manufacturer specifications. The specific cleaning protocol for the XOOM tablet is outlined in Appendix F.

## Data Collection and Procedures

### Pre Data Collection Clinic Procedures

For this study, the KU OBWCC had five staff clinicians available to perform the burn assessments. Clinician 1 was the OBWCC nurse with 7 years burn experience. Clinician 2 was the OBWCC nurse with 25 years burn experience. Clinician 3 was the OBWCC nurse with 19 years burn experience. Clinician 4 was the burn plastic surgeon/OBWCC Medical Director. Clinician 5 was the burn plastic surgeon/Department Head of Plastic Surgery. The study nurse researcher is also the OBWCC nurse practitioner who provided all of the sample patient's usual care, but also assisted in the room with tablet operation, tablet positioning, monitored the clinician completion of the Standard Burn Assessment forms, and conducted the post-assessment qualitative interviews. On any given day, at least three clinicians were available to perform the burn assessments. Clinician number/person pairings remained the same throughout the study. For example, the OBWCC nurse with 7 years burn experience was always labeled as "Clinician 1". The plastic surgeon who is the Department Head of Plastic Surgery was always labeled as "Clinician 5". A letter of support for the study was obtained from clinic management.

Prior to the start of the study, the OBWCC clinic staff (including the study nurse researcher/OBWCC nurse practitioner, receptionist, nurses, burn technologist, and burn plastic surgeons) received education/training on the purpose of the study, sample selection, inclusion and exclusion criteria, tablet device use, and the Standard Burn Assessment.

Staff education required approximately 60 minutes and occurred in the OBWCC. Personnel from the University of Kansas Telehealth/Telemedicine Department provided training on the use of the XOOM tablet to the study nurse researcher, who trained the nursing and physician staff. The nursing staff and physicians also had practiced using the tablet device on each other, performing several "dry runs" to become knowledgeable about the operation of the tablet device, and standardize study processes before the study starts. Beyond gaining expertise in the operation of the tablet, the "dry run" provided additional information regarding appropriate lighting or need for additional lighting for raters to adequately visualize the burn wound. The "dry run" helped determine that additional lighting created a glare on the tablet screen and ambient lighting provided the best viewing image. Practice with the tablet device also provided an estimate of the length of time for data collection, which was 10-20 minutes.

## Quantitative/Qualitative Data Collection and Procedures

### Overview

There are quantitative collection procedures and qualitative collection procedures. The quantitative collection procedures follow signed consent and will occur on the initial clinic visit or second clinic visit. The OBWCC nurse practitioner/study nurse researcher completed the demographic data sheet. The XOOM tablet which was mounted on a portable, adjustable, clinic approved stability device was transferred into the examination room and readied for the tablet device assessment. The First Rater performed an assessment using the tablet device, followed by a face-to-face examination. Next, the Second Rater performed an assessment using the tablet device, followed by a face-to-face examination. The First Rater and the Second Rater did not collaborate during the tablet device or face-to-face examinations.

Clinicians assigned to be First Rater and Second Rater varied depending on the availability of the clinicians on a given day but was not the person that provided usual care. One of 5 clinicians was the First Rater. A total of four burn assessments for each patient (a tablet and face-to-face assessment from two raters) were performed. The order of the face-to-face and tablet device assessments is outlined in Table 6.

Table 6
*Order of Face-to-Face and Telehealth Assessments*

| **Assessment Order** | **Observer** | **Mode** |
|---|---|---|
| A | First Rater (clinician 1,2,3,4,or 5) | Assess patient through tablet device |
| B | First Rater (clinician 1,2,3,4,or 5) | Assess patient through face-to-face encounter |
| C | Second Rater (clinician 1,2,3,4,or 5) | Assess patient through tablet device |
| D | Second Rate (clinician 1,2,3,4,or 5) | Assess patient through face-to-face encounter |

The qualitative collection procedures followed quantitative collection. A semi-structured interview occurred at the study patient's next scheduled clinic visit, which usually occurred within one week's time.

**Detailed quantitative procedures**

Following signed consent, the study nurse researcher completed the demographic information form. The XOOM tablet was brought into the examination room and initially positioned in the direction of the patient's face in order for the patient and "First Rater" to see one another. The First Rater was positioned in the nurse's station located outside the patient's examination room and introduced him/herself to the patient. After introductions, the study nurse researcher remained in the patient's examination room to assist in the operation and positioning

of the tablet device. Then, the study nurse researcher positioned the tablet device about two feet away from the burn wound to provide a more panoramic view and then repositioned the tablet device closer as the First Rater directs for a "close-up" view. The study nurse researcher further adjusted the position of the tablet device as needed per the request of the First Rater in order for the First Rater to complete the Standard Burn Assessment and record this information on the Standard Burn Assessment Form. The study nurse researcher documented the distance the tablet device was positioned from the burn wound, how often the tablet had to be repositioned in order to appropriately visualize the burn for assessment, and any technical difficulties encountered during the telehealth visit. This information was recorded on the back of the Demographic Information Sheet (Appendix A). Then, within approximately 10 minutes, the First Rater entered the patient's examination room and completed a face-to-face Standard Burn Assessment. Rationale for the order of the assessments (tablet followed by a face-to-face assessment) is derived from the study performed by Smith et al. (2004). In comparing a face-to-face assessment to a video-conferencing image, Smith found higher concordance in agreement (thus higher bias) when the initial assessments were performed through a face-to-face encounter followed by a telehealth encounter relative to assessments performed through video-conferencing followed by the face-to-face encounter.

Next, the Second Rater performed an assessment using the tablet device, followed by a face-to-face assessment. The procedures described above for the First Rater were followed by the Second Rater. Standard Burn Assessment forms were then placed in the study subject's folder. Generally, raters completed their assessments sequentially but when two burn nurses were evaluating a patient, the assessments were usually performed simultaneously. In this case, there was no interaction/collaboration between the nurses when using the tablet device to

complete the Standard Burn Assessment or when completing the Standard Burn Assessment in the face-to-face encounter.

The usual length of time a burn patient remains in the OBWCC for care ranges from 30 minutes to two hours, depending on the severity of the burn injury, the complexity of the burn dressings, and other therapies. Study procedures extended the duration of the clinic visit. This was explained during study consent procedures and in the consent form and was found to be 20 minutes longer on average.

**Detailed qualitative data collection**

To explore the patients' perception with use of a tablet device, patients were asked to participate in a short interview; interviews were conducted at their next follow-up OBWCC visit. For example, if a patient agreed to participate in the telehealth visit during the initial clinic visit, then the interview would occur at the second clinic visit. If the patient agreed to participate in the telehealth visit during the second clinic visit, then the interview would occur at their next follow-up visit. The OBWCC nurse practitioner/study nurse researcher received a list of scheduled clinic patients each day. The OBWCC nurse practitioner/study nurse researcher compared the scheduled clinic patient list to the study list to identify follow-up study patients. Of those patients currently enrolled in the study, the first 15 patients still willing to be interviewed at the end of their follow-up visit were included in the qualitative data collection. The interview occurred in the examination room. The study nurse researcher performed the interview.

There were seven open-ended questions that were used to elicit participant's perception of tablet use, as well as comfort with receiving care through a tablet device, and concerns with using the tablet device. For each question, follow-up questions were used as necessary based on

the patient's response. At the end of each interview, the study nurse researcher summarized patient responses for verification purposes. Refer to Appendix C for interview questions. The interviews were recorded and transcribed verbatim. Identifying facilitators and barriers to care can improve the application of this technology for burn care and user acceptability.

## Human Subjects Review

Approval for this study was obtained by the University of Kansas Hospital Human Subjects Committee (HSC). This study involved direct contact with patients, who were voluntary participants. The consent form identified that subjects may withdraw from the study at any time and this decision would not adversely affect or influence patient care. Subjects were reminded of this when they were asked if they were still willing to participate in the interview. Patients received the usual standard burn care in addition to the telehealth visit. Therefore, there was minimal risk for participating in the study. A subject number was designated to each consenting patient. A folder containing a list that linked the subject number with the patient's name, and each patient's signed consent form, will be kept in a secure locked location in the OBWCC until the study is completed and then the list will be discarded. Each patient also has a study folder with subject code number only that contains the demographic form (Appendix A), four Standard Burn Assessments (Appendix B), the study information sheet (Appendix E), and transcribed data from telehealth qualitative interview. Patient folders are currently located in a secure location within the OBWCC. The audio recording were digitized and stored on a KUMC secure server and the data will be retained for 15 years. Each recording was transcribed and labeled by code number and is stored in a locked file within the wound care clinic. Patient names were not mentioned in the transcripts. Only the de-identified patient's subject number

was used to enter and manage all study data in an excel file. The excel file was placed behind a firewall on a secure computer drive.

## Data Analysis

### Data Management

The nurse researcher maintained a code book, containing demographic and Standard Burn Assessment variables, with level of measurement. A log was maintained to document data analysis procedures and decisions. The study nurse researcher was responsible for collecting and de-identifying the demographic data and the data on the Standard Burn Assessments from each participant, entering the data into an excel file, and transferring the data to SPSS for analysis. Considering the nature of this study, the number of patients screened and the number of patients who gave consent was recorded, and the accrual and participation rates were reported.

### Data Set Preparation

Three separate data sets were created. This was because two of the clinicians documented multiple burn depths on several burn patients. For example, on Study Subject 45, a clinician assigned a partial thickness and deep partial thickness burn depth. This occurred on 6 encounters. The data sets include: the original data set with the multiple burn depths excluded, a data set with the multiple burn depth encounters assigned the lowest burn depth, and a data set with the multiple burn depth encounters assigned the highest burn depth. Because it is standard practice in burn care to assign a patient's burn depth at the level of the highest burn depth, the data set with the highest burn depth was chosen for the analysis of this study.

### Descriptive Statistics

Missing demographic data was retrieved from the patient's EHR, otherwise was analyzed as missing data. Descriptive statistics were performed to summarize the study variables: gender,

ethnicity, mechanism of injury, location of burn, Total Body Surface Area (TBSA) burned, and distance from home to the clinic. Descriptive statistics were used to summarize the Standard Burn Assessment results, for example, measurement of burn depth, number of patients with cellulitis, number of patients required grafting. For categorical variables, (gender, ethnicity, mechanism of injury, location of burn, burn depth, and number of patients with cellulitis), frequency and percentage were reported. For continuous variables (age, TBSA burned, and distance from the OBWCC), mean and standard deviation (SD) were reported.

**Percent Agreement**

The simplest measure of agreement between raters is the percentage of cases on which they agree. Percent agreement is the proportion of the number of cases on which two raters' codes matched divided by the total number of cases coded (Krippendorff, 2011). More specifically, it is calculated by adding up the number of cases that received the same rating by two or more raters and dividing that number by the total number of cases rated by the raters (http://conqir-idr.org/literature/LR_InterraterReliability_JT.pdf). For this study, a percent agreement was calculated as a measure of the extent of agreement between raters for each component of the Standard Burn Assessment.

**Cohen's Kappa**

There are three benchmarking scales used in reliability testing: Landis and Koch, Fleiss, and Altman (Kwet, 2012). This study used the Landis and Koch kappa scale to evaluate strength of agreement (see Table 7). A kappa value of 0.80 for the 6 assessments was considered the acceptable threshold of agreement. Table 7 describes the Landis and Koch scale.

Table 7
*Landis and Koch Kappa Scale*

| Kappa Statistic | Strength of Agreement |
|---|---|
| < 0.00 | Poor |
| 0.00 to 0.20 | Slight |
| 0.21 to 0.40 | Fair |
| 0.41 to 0.60 | Moderate |
| 0.61 to 0.80 | Substantial |
| 0.81 to 1.00 | Almost Perfect to Perfect |

A kappa can be weighted or non-weighted. The decision to use a weighted or non-weighted kappa depends on whether there is interest in the level of disagreement between values in the measuring scale being evaluated (Sim & Wright, 2005; Kwet, 2012). A weighted kappa attaches greater emphasis to large differences between ratings than small differences.

For categorical dichotomous and multilevel nominal scale variables, the degree of disagreement is weighted equally. The variables in this study are considered categorical dichotomous or multilevel nominal scale variables and an unweighted kappa value was calculated, with a two-tailed 95% confidence interval. A p-value of < 0.05 was established. In this case, the p-value tests whether the estimated kappa value is not due to chance (Viera & Garrett, 2005). The equation for calculating Cohen's Kappa is as follows:

$$\kappa = \frac{p_a - p_\varepsilon}{1 - p_\varepsilon}$$

where $p_a$ = the proportion of observations in agreement and $p_\varepsilon$ = the proportion in agreement due to chance (http://www.real-statistics.com/reliability/cohens-kappa).

The following assessments were included in the analysis of Cohen's Kappa (Table 8):

- First Rater assessments in a face-to-face encounter (Assessment A)
- First Rater assessments using the tablet device (Assessment B)
- Second Rater assessments in a face-to-face encounter (Assessment C)

- Second Rater assessments using the tablet device (Assessment D)

Table 8
*Pairings of Rater and Modality of Assessment of Face-to-Face vs Tablet Device*

| Subject number | A | B | C | D |
|---|---|---|---|---|
| | First Rater/ Face-to-Face | First Rater/ tablet device | Second Rater/ Face-to-Face | Second Rater/ tablet device |
| 1 | $item_{1-5}$ | $item_{1-5}$ | $item_{1-5}$ | $item_{1-5}$ |
| … | … | … | … | … |
| 50 | $item_{1-5}$ | $item_{1-5}$ | $item_{1-5}$ | $item_{1-5}$ |

**Spearman Correlation Coefficient**

Spearman correlation coefficient ($r_s$) is a non-parametric statistical measure of the strength of the monotonic relationship between two sets of ratings. Assumptions to use a Spearman Correlation include the rankings must be interval or ratio level variables, there must be two matched rankings, and the rankings must have a monotonic relationship.

The equation for calculating a Spearman Correlation is as follows:

$$r_s = 1 - \frac{6 \sum D^2}{N^3 - N}$$

The value of $r_s$ should be between -1 (perfect negative relationship) and +1 (perfect positive relationship, where a 0 connotes no relationship, $-1 \leq r_s \leq +1$.

The interpretation of the Spearman Correlation is as follows:

- .00 - .19 very weak
- .20 - .39 weak
- .40 - .59 moderate
- .60 - .79 strong
- .80 – 1.0 very strong

(http://www.statstutor.ac.uk/resources/uploaded/spearmans.pdf)

A two-tailed 95% confidence interval (CI) and p- value were also computed. The p-value was calculated to determine the chance the correlation coefficient was due to random sampling. The

p-value does not indicate the strength of the correlation. Instead, a p-value of .05 means there is less than a 5% chance that the correlation coefficient happened by chance (https://statistics.laerd.com/statistical-guides/spearmans-rank-order-correlation-statistical-guide-2.php). For this study, a Spearman correlation >.60 is the acceptable threshold.

For Research Question #1A, inter-rater reliability was measured as the agreement between:

Assessments A and C:

- First Rater assessments in a face-to-face encounter (Assessment A)
- Second Rater assessments in a face-to-face encounter (Assessment C)

Assessments B and D:

- First Rater assessments using the tablet device (Assessment B)
- Second Rater assessments using the tablet device (Assessment D)

For Research Question #1B, the Inter-modality reliability was measured as the agreement between: Assessments A and B:

- First Rater assessments in a face-to-face encounter (Assessment A)
- First Rater assessments using the tablet device (Assessment B)

Assessments C and D:

- Second Rater assessments in a face-to-face encounter (Assessment C)
- Second Rater assessments using the tablet device (Assessment D)

For Research Question #1C, the reliability across raters and modalities was measured as the agreement between:

Assessments A and D:

- First Rater assessments in a face-to-face encounter (Assessment A)

- Second Rater assessments using the tablet device (Assessment D)

Assessments B and C:

- First Rater assessments using the tablet device (Assessment B)
- Second Rater assessments in a face-to-face encounter (Assessment C)

**Quantitative Analysis by Research Question**

Data for addressing Research Question #1 consisted of the First Rater and Second Rater assessments for each of the five/six components of the Standard Burn Assessment for each modality across 50 subjects.

***Research Question #1***

Question #1: What is the reliability of a tablet device for performing each component of the Standard Burn Assessment (burn depth, purulent drainage, periwound rash, cellulitis, edema, and if grafted, graft take) compared to the usual face-to-face encounter?

a) What is the inter-rater reliability for each component of the Standard Burn Assessment by each modality?

a1) between two raters in a face-to-face encounter?

***Analysis:*** Unweighted Cohen's kappa for each component of the Standard Burn Assessment and percent agreement were calculated. The 95% confidence interval (CI) and p-value of kappa were also computed.

a2) between two raters using a tablet device?

***Analysis:***

Unweighted Cohen's kappa and percent agreement for each component of the Standard Burn Assessment were calculated. The 95% confidence interval (CI) and p-value of kappa were also computed.

b) What is the inter-modality reliability for each component of the Standard Burn Assessment for each rater?

b1) between a tablet device and face-to-face encounter as evaluated by the First Rater?

***Analysis:***

Unweighted Cohen's kappa and percent agreement for each component of the Standard Burn Assessment were calculated. The 95% confidence interval (CI) and p-value of kappa were also computed.

b2) between a tablet device and face-to-face encounter as evaluated by the Second Rater?

***Analysis:***

Unweighted Cohen's kappa and percent agreement for each component of the Standard Burn Assessment were calculated. The 95% confidence interval (CI) and p-value of kappa were also computed.

c) What is the reliability for each component of the Standard Burn Assessment across raters and modalities (tablet device and face-to-face encounter)?

c1) between the First rater in a face-to-face encounter and the Second Rater using a tablet device?

***Analysis:***

Unweighted Cohen's kappa and percent agreement for each component of the Standard Burn Assessment were calculated. The 95% confidence interval (CI) and p-value of kappa were also computed.

c2) What is the reliability for each component of the Standard Burn Assessment between the first rater using a tablet device and the second rater using a face-to face encounter?

***Analysis:***

Unweighted Cohen's kappa and percent agreement for each component of the Standard Burn Assessment were calculated. The 95% confidence interval (CI) and p-value of kappa were also computed.

***Research Question #2***

Data for addressing Research Question #2 consisted of the First Rater and the Second Rater Standard Burn Assessments for each modality across 50 subjects. Descriptive and inferential statistics were used to describe the overall agreement/reliability of the Standard Burn Assessment between raters and modality. The overall agreement of the Standard Burn Assessment was described by the range of kappa values for each component. Inferential statistics were used to describe the overall reliability of the Standard Burn Assessment between raters and modality. Inferential statistics were performed by Spearman correlation via coding that converts the item categories into numerical (ordinal) values. Each of the components of the Standard Burn Assessment (burn depth, purulence, rash, cellulitis, edema, and STSG) was numerically coded. The variables (burn depth, purulence, rash, cellulitis, edema, and STSG) were coded as "0" for not present and "1" for present. Ordinal level variables (burn depth and graft take) with more than two possible outcomes (burn depth = partial thickness, deep partial thickness, full thickness, and not applicable; and STSG = good graft take, no graft take, and not applicable) were dummy coded. For example, if a patient had a partial thickness burn, burn depth was coded as a "1" for partial thickness, and "0" for deep partial thickness and "0" for full

thickness burn depth. For this same patient, skin graft was also dummy coded as "0" for not applicable. For each subject, the average of all Standard Burn Assessment components was calculated. Specifically, for each patient the numerical values for (burn depth, purulence, rash, cellulitis, edema and skin graft take) were averaged and produced a value. Then, the sum of those values across all components (burn depth, purulence, rash, cellulitis, edema and skin graft take) and each modality (face-to-face and tablet) were used to compute the Spearman correlation along with its 95% CI and p-value, (refer to Appendix F).

Question #2: What is the overall reliability of a tablet device for performing a Standard Burn Assessment (SBA) (burn depth, purulent drainage, periwound rash, cellulitis, edema, and if grafted, graft take) compared to the usual face-to-face encounter?

a) What is the overall inter-rater reliability of the Standard Burn Assessment for each modality?

a1) between two raters in a face-to-face encounter?

***Analysis:***

A Spearman correlation was calculated for the averages of the binary values of applicable items between the first rater and the second rater using a face-to-face encounter (Assessments A and C, Table 9). The 95% confidence interval (CI) and p- value were also computed.

a2) between two raters using a tablet device?

***Analysis:***

A Spearman correlation was calculated for the averages of binary values of applicable items between the first rater and the second rater using a tablet

device (Assessments B and D, Table 9). The 95% confidence interval (CI) and p-value of kappa were also computed.

b) What is the overall inter-modality reliability of the Standard Burn Assessment for each rater?

b1) between a tablet device and face-to-face encounter as evaluated by the First Rater?

***Analysis:***

A Spearman correlation was calculated between the averages of binary values of applicable items of a face-to- face encounter and those of a tablet device evaluated by the first rater (Assessments A and B, Table 9). The 95% confidence interval (CI) and p-value were also computed.

b2) between a tablet device and face-to-face encounter as evaluated by the Second Rater?

***Analysis:***

A Spearman correlation was calculated between the averages of binary values of applicable items of a face-to-face encounter and those of a tablet device evaluated by Rater 2 (Assessments C and D, Table 9). The 95% confidence interval (CI) and p-value were also computed.

c) What is the overall reliability of the Standard Burn Assessment between two raters and two modalities?

c1) between the First rater in a face-to-face encounter and the Second rater using a tablet device?

***Analysis:***

A Spearman correlation was calculated for reliability between the averages of the binary values of the applicable items of the first rater using face-to-face encounter and the second rater using a tablet device (Assessments A and D, Table 9). The 95% confidence interval (CI) and p-value were also computed.

c2) between the First Rater using a tablet device and the Second Rater in a face-to-face encounter?

***Analysis:***

A Spearman correlation was calculated for reliability between the averages of binary values of the applicable items between the first rater using a tablet device and the second rater using face-to-face encounter (Assessments B and C, Table 9). The 95% confidence interval (CI) and p-value were also computed.

***Research Question #3***

Data for Research Question #3 consisted of the first and the second rater's ability to adequately visualize the wound for each component of the Standard Burn Assessment across 50 subjects. This was only done on tablet device assessments.

Question #3: What is the feasibility of using a tablet device to perform a Standard Burn Assessment?

The First and Second Rater evaluated each component of the Standard Burn Assessment (burn depth, purulent drainage, periwound rash, cellulitis, edema, and graft take) for *adequacy of visualization for assessment and clinical decision-making*, (yes/no). For patients grafted, there

will be no comment for *adequacy of visualization for burn depth.* For patients not grafted, there was no comment for *adequacy of visualization for graft take.* The frequency of "yes" and "no" responses were calculated. For those components with a "no" response, raters were asked to provide comments for the reason for inadequate visualization. The comments were categorized to provide insight for the reason for inadequate visualization across raters. In addition, the number of times the tablet device was repositioned in order for the rater to adequately visualize the burn was assessed.

**Qualitative Analysis by Research Question**

Question #4: What are burn patients' perceptions of using a tablet device in burn care?

Content analysis was conducted to describe burn patients' perspective with using the tablet device. Conventional content analysis is used when the aim of a study is to describe a phenomenon. This approach is appropriate when theory and literature related to the phenomenon are minimal (Granheim & Lundman, 2004). The analytic procedure included several phases: organization of the data, coding the data, and generating categories and themes, (Marshall & Rossman, 2010). The transcribed interviews were reviewed by the nurse researcher and coded to provide the initial themes and categories. Through repetitive, comparative analysis, the interview data was used to impart greater understanding of the patient's perspective surrounding the use of a tablet device in burn care. Understanding patients' experience with telehealth use and their confidence in the provider's ability to provide the same or better standard of care will potentially modify current burn practice and protocols.

# CHAPTER IV RESULTS

This feasibility study examined the reliability of using a tablet device to perform an outpatient standard burn assessment compared to the usual face-to-face examination. A secondary purpose described participant perceptions with use of the tablet device. This chapter presents the analytic findings including a description of the study sample variables (gender, age, and ethnicity), their burn wound mechanism of injury, location of burn, and Total Body Surface Area (TBSA) burned. Burn depth, number of patients with cellulitis, and number of patients grafted, and patient distance from home to the clinic are also detailed. In addition, this chapter provides the results of research questions including the reliability of a tablet device for performing each component of the Standard Burn Assessment (burn depth, purulent drainage, periwound rash, cellulitis, edema, and if grafted, graft take) compared to the usual face-to-face encounter, the overall reliability of a tablet device for performing a Standard Burn Assessment (SBA) (burn depth, purulent drainage, periwound rash, cellulitis, edema, and if grafted, graft take) compared to the usual face-to-face encounter, and the feasibility of using a tablet device to perform a Standard Burn Assessment. Finally, this chapter provides a qualitative analysis of the patient interviews and the themes that emerged relevant to the patients' perception of having their burn examined through a tablet device.

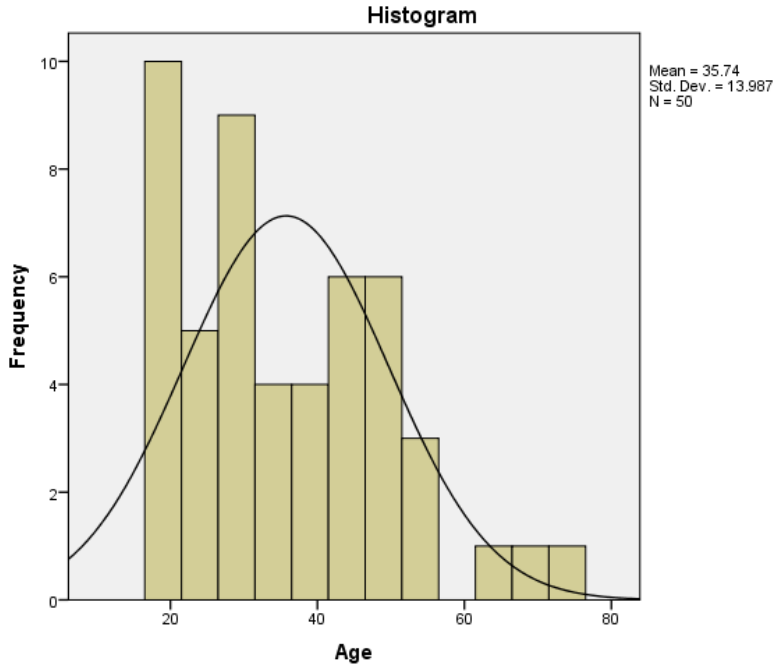
## Descriptive Statistics

### Demographic Variables

The sample included 50 patients, 48 (96%) were non-hispanic, and 2 (4%) were Hispanic (Table 10). Among the 50 patients, there were 14 (28%) females and 36 (72%) males, 44 (88%) were white and 6 (12%) were black.

The ages ranged from 19 to 76 years, with a mean age of 36 years (SD = 13.99) (Figure 2).

Figure 2
Histogram of Age




The mechanism of patient burn injury resulted mostly from flame (n = 24; 48%), grease (n =11; 22%), contact (n = 8; 16%), scald (n = 5; 10%), and electrical (n = 2; 4%) (Table 9). More than half (66%) of the patients had burn injuries involving the upper extremity. Sixteen (32%) of the burn injuries were located on the hand and 17 (34%) involved the forearm, wrist, and/or upper arm. Twenty-two percent of the burn injuries were located on the lower extremity, with 6 (12%) on the lower leg, 2 (4%) on the foot alone, 1 (2%) on the lower leg and foot, and 2 (4%) involving the thigh and lower leg. Twelve percent of the burn injuries were located on the chest, abdomen, or lower back. Four (8%) of the burns were located on the abdomen, 1 (2%) of the burns were located on the chest and abdomen, and 1 (2%) of the burns was located on the lower back.

Table 9
*Characteristics of the Sample and their Burn Injuries (N = 50 patients)*

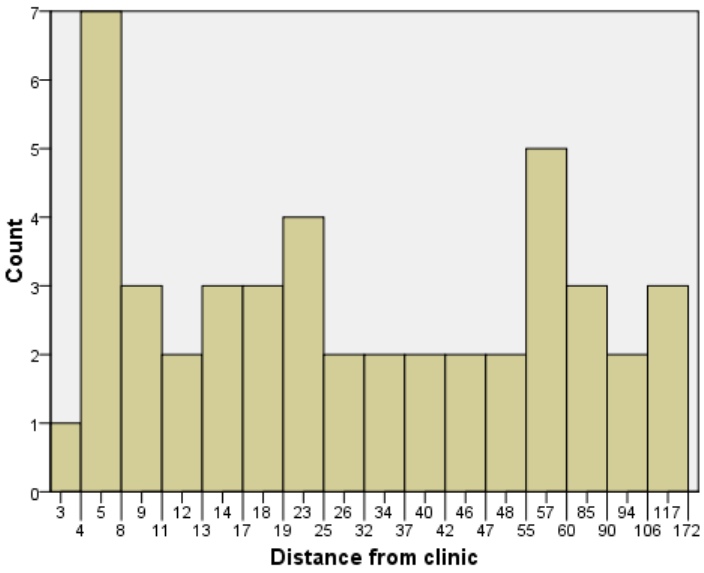
| | **N of Patients** | **% of Patients** | **N of Burn Patients** | **% of Burn Patients** |
|---|---|---|---|---|
| **Gender** | | | | |
| Male | 36 | 72 | | |
| Female | 14 | 28 | | |
| **Ethnicity** | | | | |
| Non-Hispanic | 2 | 4 | | |
| Hispanic | 48 | 96 | | |
| **Race** | | | | |
| White | 44 | 88 | | |
| Black | 6 | 12 | | |
| **Mechanism of Burn Injury** | | | | |
| Flame | | | 24 | 48 |
| Grease | | | 11 | 22 |
| Contact | | | 8 | 16 |
| Scald | | | 5 | 10 |
| Electrical | | | 2 | 4 |
| **Location of Burn Injury** | | | | |
| Forearm/Wrist/Upper Arm | | | 17 | 34 |
| Hand | | | 16 | 32 |
| Chest/Abdomen/Back | | | 6 | 12 |
| Lower Leg | | | 6 | 12 |
| Thigh/Lower Leg/Foot | | | 3 | 6 |
| Foot Alone | | | 2 | 4 |
| **Total Body Surface Area Burned** | | | | |
| Less than 1% | | | 19 | 38 |
| 1% | | | 5 | 10 |
| 2% | | | 11 | 22 |
| 3% | | | 2 | 4 |
| 4% | | | 7 | 14 |
| 5-8% | | | 6 | 12 |

**%** = percent

Total body surface area (TBSA) burned ranged from 1% to 8% (average TBSA 2%) (Table 9). Of the 50 patients, there were 19 patients (38%) with a TBSA less than 1%, 5 patients (10%) with a TBSA of 1%, 11 patients (22%) with a TBSA of 2%, 2 patients (4%) with a TBSA of 3%, 7 patients (14%) with a TBSA of 4%, and 5 patients (12%) with TBSA between 5 and 8%.

Patients traveled 3 to 172 miles to the clinic for burn care, the average distance being 39 miles (Figure 3). Of the 50 patients, 12 (24%) patients lived within 10 miles of the clinic, 12 (24%) of the patients lived within 11 to 24 miles of the clinic, 13 (26%) of the patients lived within 25 to 55 miles, and 11 (22%) lived within 56 to 172 miles. Two patients were visiting from out of town when they presented to the clinic for treatment and their distance from the clinic was not included in this analysis.

Figure 3
Histogram of Distance from the Clinic (in miles)




**Standard Burn Assessment Variables**

There were five Clinicians in this study, three burn nurses and two burn plastic surgeons. Clinician 1 was the burn nurse with 7 years burn experience. Clinician 2 was the burn nurse with 25 years burn experience. Clinician 3 was the burn nurse with 19 years burn experience. Clinician 4 was the burn plastic surgeon/OBWCC Medical Director. Clinician 5 was the burn plastic surgeon/Department Head of Plastic Surgery. For each patient encounter, there were two raters assessing the burn wound. The majority of the ratings were performed by the burn nurses,

Rater 1 was a burn nurse for 76% of the patient sample and Rater 2 was a burn nurse for 92% of the patient sample. Specifically, Clinician 1 was Rater 1 for 19 (38%) of the study subjects and as Rater 2 for 13 (26%) of the study subjects. Clinician 2 was Rater 1 for 13 (26%) of the study subjects and Rater 2 for 21 (42%) of the study subjects. Clinician 3 was Rater 1 for 6 (12%) of the study subjects and Rater 2 for 12 (24%) of the study subjects. Clinician 4 and 5 performed most often as Rater 1. Specifically, Clinician 4 was Rater 1 for 3 (6%) of the study subjects and as Rater 2 for 3 (6%) of the study subjects. Clinician 5 was Rater 1 for 9 (18%) of the study subjects and as Rater 2 for 1 (2%) of the study subjects. Figures 4 and 5 illustrate the Clinician - Rater relationship.

Figure 4

*Illustration of Clinician Performing Burn Assessments as Rater 1*

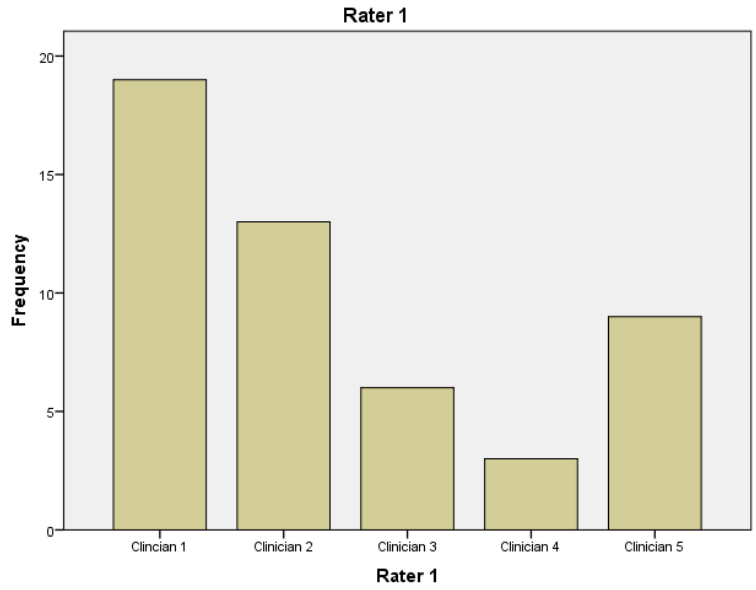
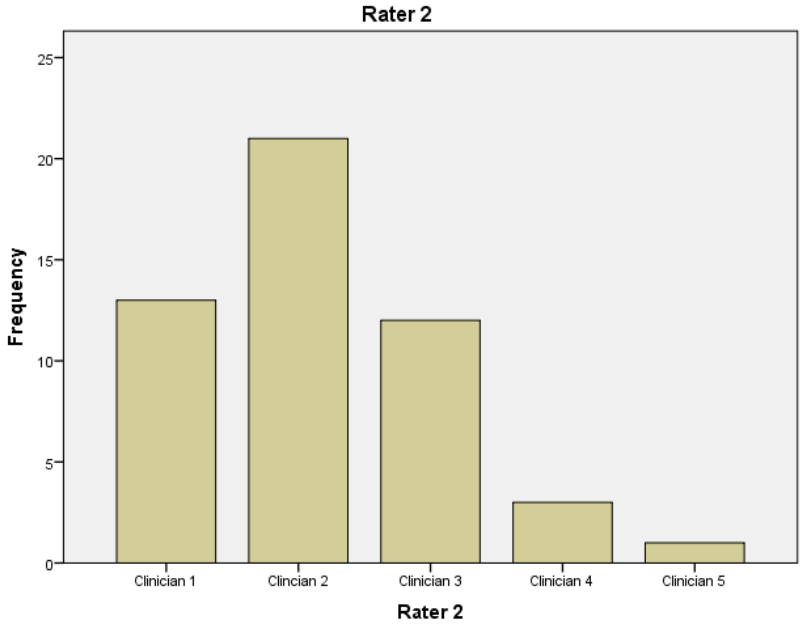


Figure 5
*Illustration of Clinician Performing Burn Assessments as Rater 2*




A description of the Standard Burn Assessment components (burn depth, purulence, rash, cellulitis, edema, and graft take) as determined by the first rater and the second rater and by mode of delivery is presented in Table 10. For burn depth, the first rater assigned a depth of partial thickness in 24 (48%) of the 50 patients when using the tablet compared to 23 (46%) in a face-to-face encounter. The second rater assigned a depth of partial thickness in 21 (42%) of the 50 patients when using the tablet compared to 21 (42%) in a face-to-face encounter. For a deep partial thickness burn, the first rater assigned a depth of deep partial thickness in 15 (30%) of the 50 patients when using a tablet compared to 16 (32%) in a face-to-face encounter. The second rater assigned a depth of deep partial thickness in 17 (34%) of the 50 patients when using a tablet compared to 17 (34%) in a face-to-face encounter. For a full-thickness burn injury, the first rater assigned a burn depth of full thickness in 6 (12%) of the 50 patients using a tablet device

Table 10
*Descriptive Data of the Standard Burn Assessment components by Rater (Rater 1 and Rater 2) and Mode of Assessment (Tablet and FTF encounter)*

| | Rater 1 | | | | Rater 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | Tablet | | FTF | | Tablet | | FTF | |
| | N | % | N | % | N | % | N | % |
| Partial Thickness | 24 | 48 | 23 | 46 | 21 | 42 | 21 | 42 |
| Deep Partial Thickness | 15 | 30 | 16 | 32 | 17 | 34 | 17 | 34 |
| Full Thickness | 6 | 12 | 6 | 12 | 7 | 14 | 7 | 14 |
| Purulence | 5 | 10 | 5 | 10 | 3 | 6 | 3 | 6 |
| Rash | 0 | 0 | 1 | 2 | 2 | 4 | 1 | 2 |
| Cellulitis | 4 | 8 | 5 | 10 | 3 | 6 | 3 | 6 |
| Edema | 19 | 38 | 20 | 40 | 18 | 36 | 22 | 44 |
| Good Graft Take | 4 | 80 | 4 | 80 | 4 | 80 | 3 | 60 |

FTF = face-to-face; % = percent; N = number of patients in the sample the rater assigned a Component of the Standard Burn Assessment in a tablet assessment and a face-to-face encounter

compared to 6 (12%) of the patients in a face-to-face encounter; the second rater assigned a burn depth of full-thickness in 7 (14%) of the patients using a tablet device and 7 (14%) in a face-to-face encounter. Five patients (10%) did not have a burn depth assigned because the burn had been grafted.

For purulence, the First Rater assigned a positive finding in 10% of the patients when using a tablet device and also in a face-to-face encounter. The Second Rater assigned a positive finding of purulence in 6% of the patients using a tablet device and in a face-to-face encounter. Assessment of cellulitis by Rater had similar findings between raters but varied across modalities. When assessing for a rash, the First Rater did not assign a rash to any patient when using the tablet device (0%) but assigned a rash to one patient (2%) in the face-to-face encounter. For edema, the First Rater visualized edema in 38% of the patients when using the tablet device

compared to 40% in the face-to-face encounter. The Second Rater visualized edema using the tablet device in 36% of the patients compared to 44% in the face-to-face encounter. Of the 50 patients, 5 patients underwent grafting. Of these 5 patients, the First Rater visualized a good graft take in 4 (80%) using a tablet device and 4 (80%) in the face-to-face encounter. The Second Rater visualized a good graft take in 4 (80%) using a tablet device and 3 (60%) in a face-to-face encounter.

**Reliability of the Standard Burn Assessment**

**Reliability for Each Component of the Standard Burn Assessment**

For 50 patients, raters were asked to complete a Standard Burn Assessment through two different modalities, a tablet device and a face-to-face encounter. The reliability for each component of the Standard Burn Assessment (burn depth, purulence, rash cellulitis, edema, and STSG) was examined by sub-question: the inter-rater reliability for each component of the Standard Burn Assessment by modality (between two raters in a face-to-face encounter, and between two raters using a tablet device), the inter-modality reliability for each component of the Standard Burn Assessment for each rater (between a tablet device and face-to-face encounter as evaluated by the First Rater, between a tablet device and face-to-face encounter as evaluated by the Second Rater), and the reliability for each component of the Standard Burn Assessment across raters and modalities (between the First rater in a face-to-face encounter and the Second Rater using a tablet device, between the Second Rater in a face-to-face encounter and the First Rater using a tablet device).

**Inter-rater reliability between each component of the Standard Burn Assessment by modality.**

The inter-rater reliability for each component of the Standard Burn Assessment (burn depth, purulence, rash cellulitis, edema, and if grated, percent graft take) was analyzed from ratings made by Rater 1 and Rater 2 in a face-to-face encounter and are presented in Table 11.

Table 11
*The Reliability for each Component of the SBA between Two Raters in a FTF Encounter*

| Between 2 Raters in FTF | Kappa (N = 50) | SE | 95% Confidence Interval | | p | Percent Agreement (%) |
|---|---|---|---|---|---|---|
| | | | Lower | Upper | | |
| **Burn Depth** | 0.762 | .078 | 0.609 | 0.915 | .000 | 88.8 |
| **Purulence** | 0.459 | .226 | 0.016 | 0.912 | .001 | 92.0 |
| **Rash** | 0.0 | .014 | 0.0 | 0.007 | .885 | 96.0 |
| **Cellulitis** | 0.730 | .180 | 0.337 | 1.0 | .000 | 96.0 |
| **Edema** | 0.426 | .129 | 0.174 | 0.678 | .002 | 72.0 |
| **STSG** | 0.892 | .097 | 0.702 | 1.0 | .000 | 98.0 |

SBA = Standard Burn Assessment; FTF = face-to-face; N = sample size of 50 patients; SE = Standard Error; STSG = Split-Thickness Skin Graft; p value < .05 denotes statistical significance

The inter-rater reliability for Rater 1 and Rater 2 for each component of the Standard Burn Assessment (burn depth, purulence, rash cellulitis, edema, and if grated, percent graft take) was analyzed from ratings made by Rater 1 and Rater 2 using a tablet device and are presented in Table 12. In a face-to-face encounter, the inter-rater reliability between Rater 1 and Rater 2 was highest for skin graft (Kappa = 0.892, SE = .097, 95% [CI 0.702, 1.0], p = .000; percent agreement = 98%). For burn depth and cellulitis, percent agreement was 88.8% and 96.0% respectively. The Kappa value for burn depth was 0.762 (SE = .078, 95% CI [0.609, 0.915], p = .000) and the Kappa value for cellulitis was 0.730 (SE 0.730, 95% CI [0.337, 1.0], p = .000) indicating substantial agreement between the raters. Ratings on purulence (Kappa = 0.459, SE 0.226, 95% CI [0.016, 0.912], p = .001) and edema (Kappa = 0.426, SE .129, 95% CI [0.174, 0.678], p = .002) showed moderate agreement but both were statistically significant.

Comparison of Rater 1 and Rater 2 rating on rash yielded a Kappa of 0.0 (SE .226, 95% CI [0.0, 0.007], p = .885) indicating poor agreement, however, percent agreement for this measure was 96%.

Table 12
*The Reliability for each Component of the SBA between Two Raters Using a Tablet*

| **Between 2 Raters using Tablet** | **Kappa (N = 50)** | **SE** | **95% Confidence Interval** | | **p** | **Percent Agreement (%)** |
|---|---|---|---|---|---|---|
| | | | **Lower** | **Upper** | | |
| **Burn Depth** | 0.731 | .080 | 0.574 | 0.888 | .000 | 89.0 |
| **Purulence** | 0.189 | .210 | 0.0 | 0.601 | .165 | 88.0 |
| **Rash** | * | | | | | 96.0 |
| **Cellulitis** | 0.847 | .150 | 0.553 | 1.0 | .000 | 98.0 |
| **Edema** | 0.576 | .119 | 0.343 | 0.809 | .000 | 80.0 |
| **STSG** | 0.892 | .097 | 0.702 | 1.0 | .000 | 98.0 |

SBA = Standard Burn Assessment; N = sample size of 50 patients; SE = Standard Error; STSG = Split-Thickness Skin Graft; p-value < .05 denotes significance. * = Kappa not calculated because the ratings from Rater 1 by tablet was constant

Between two raters using a tablet device, ratings on split-thickness skin graft (STSG) indicated near perfect agreement (Kappa = 0.892, SE = .097, 95% CI [0.702, 1.0], p = .000). Relative to the face-to-face encounter, ratings on cellulitis showed improved (near perfect) agreement (Kappa = 0.847, SE .150, 95% CI [0.553, 1.0], p = .000) when using the tablet device. Percent agreement was also slightly higher (98%). Ratings on burn depth indicated substantial agreement (Kappa = 0.731, SE .080, 95% CI [0.574, 0.888], p = .000) when using a tablet device while ratings on edema demonstrated moderate agreement (Kappa = 0.576, SE .119, 95% CI [0.343, 0.809], p = .000). In contrast, comparison of ratings for purulence between the two raters revealed a Kappa value of 0.189 (SE .210, p = .165) indicating poor agreement. A Kappa value for rash was not computed because the ratings from Rater 1 by tablet were constant (Table 10). However, the percent agreement between Rater 1 and Rater 2 for rash was high at 96%. Rater 1 did not identify a rash on any patient.

**Inter-modality reliability between each component of the Standard Burn Assessment for each rater.**

The inter-modality reliability for each component of the Standard Burn Assessment (burn depth, purulence, rash cellulitis, edema, and STSG) made from a tablet device and in a face-to-face encounter by the First Rater is presented in Table 13. For the First Rater, comparison of ratings for skin graft found perfect agreement (Kappa = 1.0, SE .000, p = .000; percent agreement = 100%). Kappa values of 0.959 (SE = .042, 95% CI [0.876, 1.0], p = .000) for edema and 0.848 (SE .065, 95% CI [.721, .975], p = .000) for burn depth indicated near perfect agreement. Percent agreement for edema and burn depth was also high (98% and 90%, respectively. In contrast to the comparison across raters, which controlled for the modality, comparison of the ratings on purulence indicated substantial agreement (Kappa = 0.778, SE .151, 95% CI [0.482, 1.0], p = .000). For cellulitis, the Kappa value was 0.390 (SE .219, 95% CI [0.0, 0.829], p = .005), indicating fair agreement, although the percent agreement was high (90%). A Kappa value for rash could not be calculated because at least one variable remained constant. Percent agreement for rash was 98%.

Table 13
*The Inter-modality Reliability for each Component of the SBA for Rater 1*

| **Between Tablet Device and FTF by Rater 1** | **Kappa (N = 50)** | **SE** | **95% Confidence Interval** | | **p** | **Percent Agreement (%)** |
|---|---|---|---|---|---|---|
| | | | **Lower** | **Upper** | | |
| **Burn Depth** | 0.848 | .065 | 0.721 | 0.975 | .000 | 90.0 |
| **Purulence** | 0.778 | .151 | 0.482 | 1.0 | .000 | 96.0 |
| **Rash** | 0.0 | .020 | --------- | -------- | .837 | 98.0 |
| **Cellulitis** | 0.390 | .219 | 0.0 | 0.829 | .005 | 90.0 |
| **Edema** | 0.958 | .042 | 0.876 | 1.0 | .000 | 98.0 |
| **STSG** | 1.0 | .000 | --------- | --------- | .000 | 100.0 |

SBA = Standard Burn Assessment; N = sample size of 50 patients; FTF = face-to-face; SE = Standard Error; STSG = Split-Thickness Skin Graft; p value < .05 denotes significance.

The inter-modality reliability for each component of the Standard Burn Assessment made from a tablet device and in a face-to-face encounter by the Second Rater are presented in Table 14. Percent agreement between ratings was high ranging from 90% to 100%. Similar to the First Rater, comparison of ratings made by the Second Rater for skin graft revealed perfect agreement (Kappa = 1.0, SE .000, p = .000). Kappa values of 1.0 (SE = .000, p = .000) for burn depth and 0.876 (SE .069, 95% CI [0.741, 1.0], p = .000) for edema indicated perfect and near perfect agreement. Kappa values of 0.645 for purulence and cellulitis showed substantial agreement (SE = .233, 95% CI [0.188, 1.0], p = .000), with a percent agreement of 90%. However, for rash, the Kappa value was 0.0 (SE .020, p = .837) but percent agreement was high at 90%.

Table 14
*The Inter-modality Reliability for each Component of the SBA for Rater 2*

| **Between Tablet Device and FTF by Rater 2** | **Kappa (N = 50)** | **SE** | **95% Confidence Interval** | | **p** | **Percent Agreement (%)** |
|---|---|---|---|---|---|---|
| | | | **Lower** | **Upper** | | |
| **Burn Depth** | 1.0 | .000 | ------ | ------- | .000 | 100.0 |
| **Purulence** | 0.645 | .233 | 0.188 | 1.0 | .000 | 96.0 |
| **Rash** | 0.0 | .020 | 0.0 | 0.012 | .837 | 90.0 |
| **Cellulitis** | 0.645 | .233 | 0.188 | 1.0 | .000 | 96.0 |
| **Edema** | 0.876 | .069 | 0.741 | 1.0 | .000 | 92.0 |
| **STSG** | 1.0 | .000 | ------ | ------- | .000 | 98.0 |

SBA = Standard Burn Assessment; FTF = face-to-face; N = sample size of 50 patients; STSG = Split-Thickness Skin Graft; SE = Standard Error; p value < .05 denotes significance.

**Reliability for each component of the Standard Burn Assessment across raters and modalities.**

The reliability for each component of the Standard Burn Assessment as calculated by ratings made by the First Rater in face-to-face encounter and the Second Rater using a tablet is presented in Table 15. Between the First Rater in a face-to-face encounter and the Second Rater using a tablet device, ratings for skin graft assessment showed near perfect agreement (Kappa =

0.892, SE = .097, 95% CI [0.702, 1.0], p = .000; percent agreement = 100%). Comparison of ratings on burn depth assessment showed substantial agreement (Kappa = 0.762, SE =.078, 95% CI [0.609, 0.915], p = .000). Percent agreement for burn depth was 84%. Ratings on edema (Kappa = 0.538, SE = .122, 95% CI [0.299, 0.777], p = .000) and cellulitis (Kappa = 0.459, SE = .226, 95% CI [0.016, 1.0], p = .001) showed moderate agreement. Percent agreement for edema and cellulitis was 80% and 92%, respectively. The comparison of ratings on rash showed poor agreement and was not statistically significant (Kappa = 0.0, SE = .020, p = .837), however, the percent agreement was high (94%).

Table 15
*The Reliability for each Component of the SBA between Rater 1 in FTF and Rater 2 using a Tablet*

| **Between Rater 1 in FTF and Rater 2 using Tablet** | **Kappa (N = 50)** | **SE** | **95% Confidence Interval** | | **p** | **Percent Agreement (%)** |
|---|---|---|---|---|---|---|
| | | | **Lower** | **Upper** | | |
| **Burn Depth** | 0.762 | .078 | 0.609 | 0.915 | .000 | 84.0 |
| **Purulence** | 0.189 | .210 | 0.0 | 0.601 | .165 | 88.0 |
| **Rash** | 0.0 | .020 | 0.0 | 0.012 | .837 | 94.0 |
| **Cellulitis** | 0.459 | .226 | 0.016 | 1.0 | .001 | 92.0 |
| **Edema** | 0.538 | .122 | 0.299 | 0.777 | .000 | 80.0 |
| **STSG** | 0.892 | .097 | 0.702 | 1.0 | .000 | 100.0 |

SBA = Standard Burn Assessment; FTF = face-to-face; N = sample size of 50 patients; STSG = split-thickness skin graft; SE = Standard Error; $\alpha < .05$ denotes significance.

The reliability for each component of the Standard Burn Assessment between the First Rater using a tablet device and the Second Rater in a face-to-face encounter is presented in Table 16. Between the First Rater using a tablet device and the Second Rater in a face-to-face encounter, ratings for skin graft assessment revealed near perfect agreement (Kappa = 0.892, SE = .097, 95% CI [0.702, 1.0], p = .000). Comparison of ratings on burn depth showed substantial reliability (Kappa = 0.731, SE = .080, 95% CI [0.574, 0.888], p = .000), with a percent agreement of 82%. Comparison of ratings on cellulitis (Kappa = 0.540, SE = .234, 95% CI

[0.081, 0.999], p = .000), edema (Kappa = 0.465, SE = .126, 95% CI [0.218, 0.712], p = .000) and purulence (Kappa = 0.459, SE = .226, 95% CI [0.016, 1.0], p = .001) showed moderate agreement. On the other hand, percent agreement for cellulitis and purulence was high (94% and 92%, respectively).

Table 16
*The Reliability for each Component of the SBA between Rater 1 Using a Tablet and Rater 2 in FTF*

| **Between Rater 1 using Tablet and Rater 2 in FTF** | **Kappa (N = 50)** | **SE** | **95% Confidence Interval** | | **p** | **Percent Agreement (%)** |
|---|---|---|---|---|---|---|
| | | | **Lower** | **Upper** | | |
| **Burn Depth** | 0.731 | .080 | 0.574 | 0.888 | .000 | 82.0 |
| **Purulence** | 0.459 | .226 | 0.016 | 1.0 | .001 | 92.0 |
| **Rash** | * | | | | | 98.0 |
| **Cellulitis** | 0.540 | .234 | 0.081 | 0.999 | .000 | 94.0 |
| **Edema** | 0.465 | .126 | 0.218 | 0.712 | .000 | 74.0 |
| **STSG** | 0.892 | .097 | 0.702 | 1.0 | .000 | 98.0 |

SBA = Standard Burn Assessment; FTF = face-to-face; N = sample size of 50 patients; SE = Standard Error; STSG = split-thickness skin graft; $\alpha < .05$ denotes significance.

**Overall Reliability of the Standard Burn Assessment**

**Overall inter-rater reliability of the Standard Burn Assessment for each modality.**

The correlation between the ratings made by the First Rater in a face-to-face encounter and the Second Rater in a face-to-face encounter for all components of the Standard Burn Assessment was 0.710, (p = .001, 95% CI [0.538, 0.825]) indicating a strong association between these raters when the burn injury was full thickness (Table 17). However, for patients with a partial thickness burn injury (Spearman = .460, p = .001, 95% CI [0.209, 0.654]) and a deep partial thickness burn injury (Spearman = 0.586, p = .000, 95% CI [0.368, 0.743]), the strength of the correlation between raters was moderate.

Table 17
*Overall inter-rater reliability of the SBA between two Raters in a FTF encounter*

| | Spearman | 95% Confidence Interval | | p |
|---|---|---|---|---|
| | | Lower | Upper | |
| **Partial thickness** | 0.460 | 0.209 | 0.654 | .001 |
| **Deep Partial thickness** | 0.586 | 0.368 | 0.743 | .000 |
| **Full thickness** | 0.710 | 0.538 | 0.825 | .000 |

SBA = Standard Burn Assessment; FTF = Face-to-Face; P value < .05 denotes significance

The correlation between the ratings made by the First Rater from a tablet device and the Second Rater from a tablet device for all components of the Standard Burn Assessment was 0.852, (p = .000, 95% CI [.752, 0.913]) when the burn injury was partial thickness and 0.657 when the burn injury was deep partial thickness (p = .000, 95% CI [0.464, 0.790]) indicating a strong association between the ratings (Table 18). For patients with a full thickness burn injury, the strength of the association between two raters was moderate (Spearman = 0.531, p = .000, 95% CI [0.297, 0.705]).

Table 18
*Overall Inter-reliability of the SBA Between Two Raters When Using a Tablet Device*

| | Spearman | 95% Confidence Interval | | p |
|---|---|---|---|---|
| | | Lower | Upper | |
| **Partial thickness** | 0.852 | 0.752 | 0.913 | .000 |
| **Deep Partial thickness** | 0.657 | 0.464 | 0.790 | .000 |
| **Full thickness** | 0.531 | 0.297 | 0.705 | .000 |

SBA = Standard Burn Assessment; P value < .05 denotes significance

**Overall inter-modality reliability of the Standard Burn Assessment for each rater.**

The correlation between the ratings made by the First Rater from the tablet device and in a face-to-face encounter for all components of the Standard Burn Assessment was strong to very strong (Table 19). Specifically, the correlation between ratings made from a tablet device and in a face-to-face encounter for deep partial thickness burns was 0.871 (p = .000, 95% CI [0.783, 0.925]), indicating a very strong association. For patients with a full thickness burn injury and partial thickness burn injury there was a similar strong association between ratings made by the

First Rater from a tablet device and a face-to-face encounter (Spearman = 0.768, p = .000, 95% CI [0.623, 0.862, Spearman = 0.703, p = .000, 95% CI [0.528, 0.820], respectively).

Table 19
*The Overall Inter-modality Reliability of the SBA between a Tablet Device and FTF Encounter for Rater 1*

| | Spearman | 95% Confidence Interval | | p |
|---|---|---|---|---|
| | | Lower | Upper | |
| **Partial thickness** | 0.703 | 0.528 | 0.820 | .000 |
| **Deep Partial thickness** | 0.871 | 0.783 | 0.925 | .000 |
| **Full thickness** | 0.768 | 0.623 | 0.862 | .000 |

SBA = Standard Burn Assessment; FTF = Face-to-Face; P value < .05 denotes significance

For the Second Rater, the correlation between ratings from the tablet device and in face-to-face encounter on all components of the Standard Burn Assessment showed strong to very strong association (Table 20). When the burn was a deep partial thickness, the correlation between ratings from a tablet device and in a face-to-face encounter was 0.859 (p = .000, 95% CI [0.764, 0.917]), indicating a very strong association. In tandem, when the burn was a partial thickness or full thickness, the correlation between ratings from a tablet device and in a face-to-face encounter were strong (Spearman = 0.766, p = .000, 95% CI [0.620, 0.860; Spearman = 0.747, p = .000, 95% CI [0.592, 0.848], respectively).

Table 20
*The Overall Inter-modality Reliability of the SBA between Tablet Device and FTF Encounter for Rater 2*

| | Spearman | 95% Confidence Interval | | p |
|---|---|---|---|---|
| | | Lower | Upper | |
| **Partial thickness** | 0.766 | 0.620 | 0.860 | .000 |
| **Deep Partial thickness** | 0.859 | 0.764 | 0.917 | .000 |
| **Full thickness** | 0.747 | 0.592 | 0.848 | .000 |

SBA = Standard Burn Assessment; FTF = Face-to-Face; p value < .05 denotes statistical significance

**Overall reliability of the Standard Burn Assessment between two raters and two modalities.**

The correlation between ratings from the First Rater in a face-to-face encounter and the Second Rater using a tablet device on all components of the Standard Burn Assessment was moderate to strong (Table 21). Specifically, for patients with a deep partial thickness burn injury, the correlation between raters on all components of the Standard Burn Assessment was 0.645 (p = .000, 95% CI [0.447, 0.782]), indicating a strong association. For patients with a full thickness burn injury, the correlation between raters on all components of the Standard Burn Assessment was moderate (Spearman = 0.570, p = .000, 95% CI [0.347, 0.732]). For patients with a partial thickness burn injury, the correlation between raters on all components of the Standard Burn Assessment also was moderate (Spearman = 0.434, p = .000, 95% CI [0.178, 0.635]).

Table 21
*Overall Reliability of the SBA between the First Rater in a FTF Encounter and the Second Rater Using a Tablet Device*

| | Spearman | 95% Confidence Interval | | p |
|---|---|---|---|---|
| | | Lower | Upper | |
| **Partial thickness** | .434 | 0.178 | 0.635 | .000 |
| **Deep Partial Thickness** | .645 | 0.447 | 0.782 | .000 |
| **Full thickness** | .570 | 0.347 | 0.732 | .000 |

SBA = Standard Burn Assessment; FTF = Face-to-Face; p value < .05 denotes statistical significance

Conversely, the correlation between ratings from the First Rater when using the tablet device and the Second Rater in a face-to-face encounter on all components of the Standard Burn Assessment was weak to moderate (Table 22). For patients with a deep partial thickness or partial thickness burn injury, the correlation between raters revealed similar moderate associations (Spearman = 0.590, p = .000, and 95% CI [0.373, 0.745]; Spearman = 0.524, p = .000, CI [0.288, 0.7], respectively).

Table 22
*Overall Reliability of the SBA between the First Rater using a Tablet Device and the Second Rater in a FTF encounter*

| | Spearman | 95% Confidence Interval | | p |
|---|---|---|---|---|
| | | Lower | Upper | |
| **Partial thickness** | 0.524 | 0.288 | 0.700 | .000 |
| **Deep Partial thickness** | 0.590 | 0.373 | 0.745 | .000 |
| **Full thickness** | 0.399 | 0.360 | 0.609 | .004 |

SBA = Standard Burn Assessment; FTF = Face-to-Face; p value < .05 denotes statistical significance

## Feasibility of Tablet Device Use

### Adequacy to Visualize Standard Burn Assessment Components

Overall, nearly every rater felt the burn wounds could adequately be visualized through use of the tablet device (Table 23). Over the 100 encounters (50 patients with two ratings), one rater (1%) documented an inability to adequately visualize burn depth. A different rater (1%) documented an inability to adequately visualize purulence. The Various clinician comments are as follows:

From Clinician 1: Some of medial and anterior wound is difficult to see color differentiation. Image was fuzzy.

From Clinician 3: Most of the wound bed is partial thickness. Upon visual inspection [during the FTF encounter] this observer noted a quarter size to dollar size area of deep partial thickness burn injury that was not seen on the tablet image.

From Clinician 3: The appearance and color of the intact skin made me want to be able to wipe the skin to see if it would easily peel off.

From Clinician 1: Appearance of the forearm through the tablet image could be deceiving as edge with maceration shows that wound is open but proximal area is superficial area.

One clinician commented "image slightly fuzzy but able to see color". The remainder of the burn wound components (rash, cellulitis, edema, and STSG) demonstrated 100% adequacy to visualize by all raters. Although all the clinicians reported adequacy in visualization of a rash, one of the clinicians reported that after the face-to-face examination, "there wasn't a rash but the

periwound was denuded and with blisters". Clinician comments regarding cellulitis include, "able to see cellulitis but brightness of image quality could be enhanced", "more apparent on face to face encounter but seen on the tablet as well", and "erythema more readily visible in face to face than on tablet".

Table 23
*Description of Raters Ability To Adequately Visualize Standard Burn Assessment Components (N = 50 Raters)*

| SBA Components | First Rater | | | | | | Second Rater | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Adequate | | Inadequate | | N/A | | Adequate | | Inadequate | | N/A | |
| | N | % | N | % | N | % | N | % | N | % | N | % |
| Burn Depth | 44 | 88 | 1 | 2 | 5 | 10 | 45 | 90 | | | 5 | 10 |
| Purulence | 49 | 98 | 1 | 2 | | | 50 | 100 | | | | |
| Rash | 50 | 100 | | | | | 50 | 100 | | | | |
| Cellulitis | 50 | 100 | | | | | 50 | 100 | | | | |
| Edema | 50 | 100 | | | | | 50 | 100 | | | | |
| STSG | 45 | 90 | | | 5 | 10 | 45 | 90 | | | 5 | 10 |

SBA = Standard Burn Assessment; STSG = Split-Thickness Skin Graft
N/A = not applicable, burn wound grafted

## Patient Perceptions of Using a Tablet Device to Receive Burn Care

Of the 50 patients that participated in the study, 15 (10%) of the sample agreed to participate in a short interview regarding the use of a tablet device to receive burn care. A handful of patients refused to participate in the interview; the reason for refusal was not solicited. The interviews occurred in the Outpatient Burn and Wound Care Center, within 1-2 weeks of the initial burn clinic encounter. The interviews were conducted by the study nurse researcher and occurred in the examination room. No other clinic staff were present during the interview. Of the 15 patients interviewed, 9 (60%) had previous experience with using a tablet. From the study interviews, four themes emerged: (a) the patients' comfort with the tablet device, (b) the patients' confidence in receiving burn care through the use of a tablet device, (c) enhanced access to care, and (d) improved patient satisfaction.

**Patients' Comfort with Using the Technology**

All fifteen patients agreed that they would be able to use a tablet device at home in the future. Most of the patients felt the initial examination should be done face-to-face. Some patients felt, as long as the provider was comfortable with how the burn wound was progressing, they would be comfortable with having the burn evaluated by the physician or nurse using the tablet device for the remainder of the visits. "If you keep looking at it [the burn wound] and it looks good, I'd be fine not coming in for a face-to-face until you tell me I need to come in." Another patient stated,

> "It depends on how bad the burn was. If the burn was questionably deep, I think they [the patient] need to come in person. If it was definitely not a third degree burn and you treat it right and it ought to heal and you wouldn't need to be seen by the doctor at all after that unless there was a problem."

One patient felt seeing the provider every other visit in-person would make them feel comfortable. "I would prefer a face-to-face over the tablet device every other visit."

Regarding ease of tablet use, patients felt if directions on how to use the tablet were provided or a family member were available to operate the tablet and assist in changing the dressing, then "I think it would be fairly easy to use. It didn't look like it was hard to use." Another patient voices, "I would be comfortable using the tablet even though I don't like using technology." "Even if it were both hands [burns on both hands], I could have my wife or set the tablet on the table and move my hands, whatever was necessary, it would be easy to do." "It depends on who's on the other side examining me that I'm talking to. As long as I can have a

good communication back and forth, even though it's through the tablet that would be fine with me."

**Patients' Confidence in Receiving Burn Care Through Tablet Device**

Overall, all the patients felt confident that the provider could visualize the burn wound and direct appropriate burn care. Patients reported that although the tablet is not the same as a face-to-face visit, use of the tablet at home would minimize their stress. "For the most part, you're just looking at the burn and deciding if it looks good, healthy. If it doesn't look right, I'm sure you'd tell me to come in for a face-to-face." Another person states, "I think you're getting honest advice, just as if you were in person."

Patients also commented on how use of the tablet at home would provide feedback and information on burn healing and thereby minimize stress. "Being able to get in touch, see the photo, you tell me, hey you guys are on the right track, it looks great, looks normal. That would give me a great boost emotionally." Another patient echoes a similar thought. "This is a jump forward in technology. It would have been beneficial to use at home and provided piece of mind. "

Two patients commented on how the tablet is not the same as the 'gold standard'. "It's difficult to discuss disadvantages. Face-to-face is hands on. You can touch and through the tablet you can't be hands on." "You might be able to see it better in a face-to-face." Another patient states "It would have been nice to have the tablet at home so that maybe two days after I saw him [provider], I could show him how it looked. On the second and third day, we had a lot of questions on what does this look like- is it normal, is this not, does it look like it's infected."

**Improved Patient Satisfaction**

Most of the patients remarked that use of a tablet to receive burn care from home would save money in travel (no gasoline, no parking fees), and time (less time away from work, quicker visit, and more convenient appointment times). “Being a paraplegic, everything that I have to do to get from point A to point B would save me a ton of time.” “If I had to take a day off work, it would be easier to work this [telehealth] into my busy schedule.” Another patient added, “I wouldn’t have to wait in a waiting room, less paperwork, and I can be seen right away.” “If you’re on pain medication, you can’t drive and you have to get a driver or not take the pain medication. Using the tablet at home, you can take your pain medication.”

**Enhanced Access to Care**

Several patients alluded to how telehealth enhances access to care. They thought that telehealth, and use of the tablet device in burn care, could improve patient outcomes, facilitate patient care, and improve communication between providers. Also, use of the tablet from home could identify complications earlier and appropriate treatment could be implemented sooner, preventing a delay in burn wound healing. According to one patient, “If you don’t see someone for a week, you don’t know that during that week, the patient is doing the dressing right. With the tablet, you can check on the patient after a day or two. You can catch bad stuff happening further ahead using the tablet.”

Implementing telehealth in burn care can enhance access to care for remote areas, promoting communication between providers and patients separated by distance. “I think it could be a very good tool for remote hospitals and emergency rooms so the patients don’t have to drive 2-3 hours to get to a burn center. Another patient states “Our local doctor couldn’t do it [take care of the burn]. It would have been nice to show the doctors down there.” “Using the

tablet device for more long distance cases, more remote because I know we have more remote areas in our country where General Practitioners aren't equipped to handle these types of burns. So advancing the care through a tablet, to make it available to these outer lying areas is great."

Several patients thought that tablet use in burn care could facilitate earlier discharges from the burn unit, provide continuity of care, and reduce hospital costs. "Maybe you could send people home earlier from the hospital, save a lot of money for insurance companies, send them home 3-4 days earlier, check on them every day or every other day at home".

# CHAPTER V DISCUSSION

The purpose of this study was to examine the reliability of using a tablet device to perform an outpatient standard burn assessment compared to the usual face-to-face examination, as well as to describe participant perceptions with use of the tablet device. This chapter discusses the results of the study, limitations, theoretical relevance, clinical applications, and recommendations for future research.

## Importance of the Study

This is one of the first studies to examine the reliability of the tablet device for use in burn care. Moreover, it is one of the few studies to triangulate measures across modality, across rater, and across modality and rater to determine consistency of reliability of tablet device use in burn care. In addition, this is the only known study to co-examine the feasibility of tablet use and patient perceptions of tablet use for burn care.

## Discussion of Study Findings

### Demographic Variables

Comparable to previous studies, this study's sample size was similarly powered with 50 patients (Jones, et al. 2003; Hseih, et al. 2004; Shokrollahi, et al 2007; Tsai, et al 2004). Patients in this study ranged from 19 to 76 years with a mean of 36 years. Other studies included patients of similar age. In the study by Nguyen et al. (2004), the sample ranged in age from 1 to 96 years with a mean age of 31 years. Likewise, Roa et al. (1999) reported an age range from 1 to 75 years with mean age of 29 years. Subjects in the study by Hseih et al. (2004) who evaluated the use of a digital camera phone to assess soft tissue injury of the hand were 30 years of age on average.

Among the patients in this study, 88% were white and 12% were black which was similar to Jones et al. (2003) where 93% were white and less than 2% were black. Like other studies (Nguyen et al., 2004; Roa et al., 1999; Saffle, et al., 2009; Sagraves, et al., 2007; Turk, et al., 2011), the sample shared a larger percentage of male burn patients (72%) compared to female burn patients (28%).

This study found that 48% of the patients in the study suffered a flame injury followed by scald and grease. Results are similar to those by Roa et al. (1999) who found 50% of the sample suffered from a flame injury followed by scald. In contrast, only 18% of the patients in the study by Jones et al. (2003) had a flame injury, and more (50%) of the patients had a scald or contact injury.

Few studies report the location of the burn injury. In this study, more than half (66%) of the patients had burn injuries involving the upper extremity, 22% of the burn injuries were located on the lower extremity, and 12% of the burn injuries were located on the chest, abdomen, or lower back. In contrast, Roa et al. (1999) described most of their burn injuries occurring on the lower extremity (42%), followed by the upper extremity (37%), and trunk (16%).

The setting for this study was an outpatient burn and wound clinic which typically provides treatment to patients with a burn injury less than 10% total body surface area; those with larger burns (> 10% TBSA), meet hospital in-patient admission criteria. In this study, the total body surface area burn ranged from 0.5% to 8% with a mean of 2% which is similar to the burn range of 0.1 to 5% with a mean of 1.2% TBSA burned found by Shokrollahi et al. (2007). Although results fell within the inclusion criteria of less than 10% total body surface area burned, findings cannot be generalized to burns greater than 8% total body surface area burned.

In general, the University of Kansas Hospital Outpatient Burn and Wound Care Center treats patients residing in Northeast Kansas, south from Emporia to Pittsburg, and west toward Manhattan, Salina, and Hays. In addition, because The University of Kansas Medical Center is on the Kansas/Missouri state line, the burn clinic also treats a significant number of Missouri residents. Most of the patients in this study (74%) lived within 55 miles of the burn clinic and only 22% of the patients lived between 56 to 172 miles from the burn clinic. Other studies reported vast distances between the specialized burn center and patient location. For example, in Australia, patients traveled an average 397 miles to the burn center from a remote telemedicine site (Smith and Youngberry et al., 2004). Even within the United States, depending on the geographic location, some patients travel over 500 miles from their home to receive treatment at a regional verified burn center (Nguyen, et al., 2004).

**Standard Burn Assessment Variables**

There were six components of the Standard Burn Assessment that were measured in this study: burn depth, presence of rash, presence of purulent drainage (purulence), presence of cellulitis, presence of edema, and if grafted, graft take. Likewise, Jones et al. (2003) assessed burn wounds for burn depth, cellulitis, erythema, edema, and infection. Among the remaining five burn studies, Sagraves et al. (2007) described total body surface area, burn depth, and burn wound infection, while Roa et al. (1999) and Shokrollahi et al. (2007) only examined burn depth. However, Smith and Kimble et al. (2004) evaluated graft take. Other telemedicine studies examined other wound characteristics (Braun, et al., 2005; Murphy, et al., 2006; Roth, et al., 1999; Tsai, et al., 2008). Braun et al. (2006) examined the wound for surrounding erythema. Murphy et al. (2006) assessed the wound for depth, cellulitis, purulence, and edema. Roth et al. (1999) evaluated the wound for infection, and to determine if the wound was suitable for a skin

graft. Tsai et al. (2008) assessed the wound for erythema and cellulitis. Since the hallmark of cellulitis is surrounding erythema, this study did not measure the two clinical findings separately. A limitation of the tablet is the inability to palpate the skin surrounding the wound to assess for blanchable erythema and warmth associated with cellulitis normally possible in a face-to-face encounter. Because only small burn injuries were included in this study, total body surface area was not assessed between raters but should be evaluated in future burn studies.

Many of the burn injuries in this study were partial thickness (between 42-48%), followed by deep partial thickness (between 30-34%) and then full thickness (between 12-14%). The range in assignment by burn depth reflects differences between the raters as well as the modality (face-to-face versus tablet device). Somewhat similarly, Jones et al. (2003) found that the majority of the burns studied (62%) were partial thickness, but 22% were full thickness.

## Reliability for Each Component of the Standard Burn Assessment

### Inter-rater Reliability Between Each Component of the Standard Burn Assessment by Modality

Findings from this study revealed that the inter-rater reliability of ratings between two raters (Rater 1 and Rater 2) in a face-to-face encounter were substantial to near perfect for graft take (Kappa = 0.892), burn depth (Kappa = 0.762), and cellulitis (Kappa = 0.730). For purulence and edema, agreement between the two raters in face-to-face encounter was moderate (Kappa = 0.459 and Kappa = 0.426, respectively). Agreement between the two raters for rash was poor (Kappa = 0.0). Despite the poor Kappa value for rash, the percent agreement was high (96%). No other studies were found that performed a face-to-face assessment for comparison purposes. Even in the face-to-face encounter, the ratings between the raters only showed near perfect reliability for one component of the Standard Burn Assessment (graft take). So, although a face-

to-face examination is the standard of care, there was variation between raters in this study examining burn wound components even in a face-to-face encounter.

Similar to the findings from the face-to-face encounter, the inter-rater reliability of ratings between two raters (Rater 1 and Rater 2) using a tablet device also showed substantial to near perfect ratings for skin graft take (Kappa = 0.892), burn depth (Kappa = 0.731), and cellulitis (Kappa = 0.847). However, this study showed better agreement in the assessment of cellulitis relative to Tsai et al. (2004), who compared assessments of cellulitis/infection made from a digital cell phone image and cited only substantial reliability (Kappa = 0.61) from raters on this measure. Braun et al. (2005) evaluated wounds for surrounding erythema (an indicator of cellulitis) from a digital cell phone image and found substantial (Kappa = 0.80) and almost perfect reliability (Kappa = 0.92) between raters. In the current study, it is possible the raters were only looking for the presence of erythema instead of the presence of cellulitis. Calculation of a kappa statistic for rash was not possible because of the lack of variability in response by one or the other of the raters. The prevalence of rash was very low (2 cases/4%) thus, the kappa statistic was likely negatively affected (Sim & Wright, 2005). Indeed, the percent agreement between Rater 1 and Rater 2 that a rash was not present was 96% compared to the disagreement between Rater 1 and Rater 2 for the presence of a rash was 4%.

Comparing the face-to-face and tablet device assessments, the reliability of assessments between raters for skin graft take, burn depth, and cellulitis suggest the tablet device is as reliable as a face-to-face examination. However, the reliability of purulence from the tablet device (Kappa = 0.189) was much lower than the face-to-face assessment (Kappa = 0.459) Burn wounds are typically dry (deep partial thickness and full thickness injury) or wet (partial thickness injury), but are not particularly highly exudative. For this study, raters were asked to

assess for purulence by assessing the burn bandage once it was removed from the burn wound. The discrepancy in agreement between modalities could be attributed to one's ability to better assess for this component in a face-to-face encounter compared to a tablet device. On the other hand, the prevalence of purulence was low (Rater 1 stated there was no purulence in 90% of the patients and Rater 2 stated there was no purulence in 94% of the patients Thus, the low occurrence of purulence, regardless of a high percent agreement between raters, could have lowered the Kappa coefficient, which is influenced by low prevalence (Sim & Wright, 2005). The reliability of edema when assessed through a tablet device (Kappa = 0.576) was higher relative to the face-to-face encounter (Kappa = 0.426) but both showed only moderate inter-rater reliability. Typically, when assessing for edema, a provider will compare one extremity to another extremity. However, the raters were not instructed to compare the burn injured extremity to the non-burn injured extremity in order to determine if edema were present; this may have influenced the assessment.

**Inter-modality Reliability between Each Component of the Standard Burn Assessment for Each Rater**

Consistent with inter-rater reliability by modality, results from this study for the inter-modality reliability for each component of the Standard Burn Assessment by rater showed high reliability for the assessment of skin graft take (Kappa = 1.0) and burn depth (Kappa = 0.848 - 1.0), and also showed substantial to near perfect reliability for edema (Kappa = 0.876 - 0.958) and purulence (Kappa = 0.645 - 0.778). Interestingly, the percent agreement for edema and purulence was comparably high (98% and 96%, respectively). However, the inter-modality reliability for the assessment of cellulitis varied by rater showing only fair reliability for Rater 1 (Kappa = 0.390) and moderate reliability (Kappa = 0.645) for Rater 2, even though the percent

agreement was relatively high (90%). The inter-modality reliability for the assessment of rash was poor (Kappa = 0.0), but the percent agreement was high (98% for Rater 1 and 90% for Rater 2).

In contrast with findings from this study, when comparing a face-to-face assessment with an assessment made by the same rater using a digital image, Jones et al. (2003) found moderate agreement (Kappa = 0.60) between raters for the assessment of burn depth when categorized as full thickness, partial thickness, and superficial thickness. After differentiating partial thickness burns as superficial partial thickness or deep partial thickness, agreement on partial thickness burn depth declined even further (Kappa = 0.45). Jones et al. (2003) found similar reliability for cellulitis (Kappa = 0.40) but only moderate reliability for edema (Kappa = 0.40) compared to the current study's near perfect agreement for edema. The face-to-face assessment was performed first in the Jones et al. study (2003) and the time interval between the face-to-face evaluation and the telehealth visit was 4-6 weeks. Murphy et al. (2006) compared a face-to-face assessment to a digital image assessment of lower extremity wounds among three raters. The assessment of wound depth showed substantial reliability (Kappa = 0.6994), but results did show near perfect agreement between raters in the assessment of cellulitis (Kappa = 0.9881), purulence (Kappa = 0.9881), and edema (Kappa = 0.9404). The raters in this study performed the tablet device assessment first, followed a few minutes later by the face-to-face encounter. Notably, the *inter-modality reliability for each rater* is higher than the *inter-rater reliability for each modality* and is likely attributed to memory bias. In a related study (Shokrollahi, et al., 2007) burn patients were examined by a burn surgeon using a digital image which was followed by a face-to-face encounter. These authors also reported a strong correlation (r = .92) for burn depth assessment.

Two older studies compared the inter-rater reliability of the assessment of burns and wounds (Roth, et al., 1999; Roa, et al., 1999). Roth et al. (1999) compared a digital image to a slide image to evaluate a wound for infection, and suitability for skin graft. Compared to this study which only showed fair to moderate agreement between raters for the assessment of cellulitis (infection), Roth showed 87% overall agreement between all six raters and a correlation between the raters years of experience and the kappa value. Comparing digital images with varying compression sizes, Roa et al. (1999) found that 90% of the raters were in agreement in the assessment of burn depth, which is analogous to the current study's near perfect to perfect agreement between raters for the assessment of burn depth.

**Inter-rater Reliability for Each Component of the Standard Burn Assessment Across Raters and Modalities**

Further evidence for the reliability of the Standard Burn Assessment was provided by the analysis across raters and modalities. Results revealed near perfect reliability for skin graft take (Kappa value = 0.892). Smith and Kimble et al. (2004) compared a face-to-face assessment to an assessment made through video-conferencing and found 96% agreement between the two raters for the assessment of graft take. Like the current study, they identified an inability to perform a Kappa statistic because of the lack of variability in the components that were being assessed. Across raters and modalities, results from this study showed substantial reliability for burn depth (Kappa = 0.731 to 0.762) which is slightly similar to those from Shokrollahi, et al., (2007) who reported a high correlation in burn depth assessment (r = 0.91) between the first burn surgeon's face-to-face assessment and the second burn surgeon's telehealth evaluation. Further analysis of the Standard Burn Assessment components varied across raters and modalities. Despite a percent agreement of 92%-94% for cellulitis, the assessment of cellulitis (Kappa =

0.459 to 0.540) and edema (Kappa = 0.465 to 0.538) demonstrated moderate reliability. The assessment of purulence demonstrated poor to moderate agreement (Kappa = 0.189 to 0.459). The assessment of rash, once again, showed poor reliability (Kappa = 0.0), even though the percent agreement between raters was high (94%-98%). In the study by Tsai (2004), clinical decision between a provider who assessed the wound through the digital cell phone image and a provider who assessed the wound face-to-face (across raters and modality) were compared. The study found moderate to substantial reliability in the assessment of gangrene, necrosis, erythema, and cellulitis (between raters), however between raters and modality, 14 of the 82 wounds (17%) were mismanaged (discordance in recommendations for antibiotics or skin grafting).

Relative to the previous reliability comparisons (inter-rater reliability by modality and inter-modality reliability between raters), the assessment of skin graft take across raters and modalities demonstrated slightly lower kappa values but still near perfect reliability. The assessment of burn depth across raters and modalities was also lower (although substantial reliability) relative to the near perfect to perfect comparisons. Across raters and modality, the assessment of cellulitis showed similar moderate reliability compared to the assessment between raters but lower compared to the substantial to near perfect reliability between modality. Similarly, the assessment of edema demonstrated moderate reliability across raters and modality and between modality, but near perfect reliability between raters. The assessment of purulence was consistently poor to moderate across raters and modality and between modality, except when evaluated between raters (moderate to substantial).

## Overall Reliability of the Standard Burn Assessment

### Overall Inter-rater Reliability of the Standard Burn Assessment for Each Modality

Findings from this study suggest that the overall reliability of assessing a burn wound through a tablet device was as reliable as a face-to-face examination. In fact, the correlations between the ratings made by the First Rater and the Second Rater when using a table device (Spearman ranged from 0.531 to 0.852) were higher than the correlations from the face-to-face encounter (Spearman ranged from 0.460 to 0.710). The highest correlation occurred when raters assessed a partial thickness burn using a tablet device (Spearman correlation = 0.852). However, if the burn injury was a full thickness injury, overall reliability was stronger in a face-to-face encounter. Engel (2011) also examined the overall agreement between a face-to-face encounter compared to a smartphone assessment in the viability of free flaps. Although a percent agreement is not a direct comparison to overall agreement, the accuracy of assessment between the face-to-face assessment was 98.7% and the accuracy of assessment between the smart-phone group was 94.1%. Compared to the smart phone, Engel found the face-to-face assessment slightly better accuracy compared to this study which found the tablet device to show slightly stronger correlations.

### Overall Inter-modality Reliability of the Standard Burn Assessment for Each Rater

Findings from this study also provide support for the overall inter-modality reliability of the Standard Burn Assessment by Rater. The correlation between ratings from the tablet device and the face-to-face encounter for each rater ranged from 0.703 to 0.871. The strongest correlation occurred with deep partial thickness burns (Spearman = 0.871 and Spearman = 0.859, for Rater 1 and Rater 2 respectively). Few studies have examined the overall reliability of assessing a burn or wound between raters. Roth (1999) calculated the overall reliability of

assessing a chronic wound between a digital image and a slide image by averaging the Kappa scores and found years of experience of the rater influenced the reliability. For the present study, the majority of the ratings were performed by Clinician 1 (64%) and Clinician 2 (68%), who were experienced burn nurses compared to Clinician 4 (12%) and Clinician 5 (20%) who were experienced burn surgeons. Although there was a difference in the years of education between the raters (years of experience for a R.N. degree compared to years of experience for M.D. degree), the nursing staff shared over 60 years of burn care experience compared to the physician staff who shared 35 years of burn experience. Averaging the Kappa values across variables, Braun (2005) cited the overall reliability between two raters performing a wound assessment through a digital image compared to a face-to-face encounter was substantial (Kappa = 0.75). Examining free flaps, Engel (2011) showed high inter-rater reliability between the three smart-phone assessors, 96.1%, 91.1% and 95.1% compared to three plastic surgeons, 94.6%.

**Overall Reliability of the Standard Burn Assessment Between Two Raters and Two Modalities**

Across raters and modalities, the findings from this study reveal weak to moderate overall reliability of the Standard Burn Assessment (Spearman ranging from 0.399 to 0.645). Similar to the correlation between raters, the strongest correlation existed when the burn depth was deep partial thickness (Spearman = 0.645). This is contrary to the first comparison (inter-rater reliability between modalities) where partial thickness burns were readily discernable using a tablet device and full thickness burns were readily discernable through a face-to-face encounter. Smith & Kimble et al. (2004) studied the overall concordance of scar assessment, range of motion, and skin graft breakdown between a face-to-face and video-conferencing assessment, as well as the overall concordance between two face-to-face assessments. They found the overall

concordance in agreement between a face-to-face assessment and the video-conferencing assessment was 84%, compared to the 85% overall concordance between two face-to-face assessments. Interestingly, to describe the overall reliability between a face-to-face encounter and a telehealth encounter for chronic wound assessment, Braun et al. (2005) averaged the Kappa values across all nine measured components. Braun et al. (2005) reported an overall Kappa value of 0.74 between Rater 1 in a face-to-face encounter and Rater 2 in a telehealth encounter, and overall Kappa value of 0.82 between the same Rater 1 in a face-to-face encounter and Rater 3 in a telehealth encounter.

**Feasibility of Tablet Device Use**

In this study, the feasibility of tablet use for burn care was established by raters indicating whether or not he/she could adequately visualize the burn wound on each component of the Standard Burn Assessment. In addition, the number of times the tablet needed to be repositioned was documented as well as any issues with lighting. For each component of the Standard Burn Assessment, nearly every rater (98% – 100%) felt the burn wound could be adequately visualized through use of the tablet device. There were a few comments (n = 2) regarding the picture image on the Motorola XOOM being fuzzy and that it could possibly be enhanced. Perhaps, a newer tablet model would have provided more enhanced quality image and positively affected reliability. Study findings are consistent with previous research on observer confidence with image quality and decision-making (Braun et al., 2005; Jones et al., 2003; Roa et al., 1999; Smith & Kimble, et al., 2004). Roa et al. (1999) established with a high degree of certainty that burn depth could be reliably assessed using a camera digital image. Jones et al. (2003) found little difference in the observer confidence between the face-to-face and camera digital image assessments. In burn patients, Smith & Kimble et al. (2004) cited 100% adequacy for diagnosis

and clinical decision making using video-conferencing. In assessing chronic wounds, Braun et al. (2005) found a cell phone camera digital image to be of good quality to very good quality in almost 80% of the patients. In addition, the raters were confident about using the digital image to formulate a clinical assessment in 82% of the patients.

Anecdotally, the tablet was repositioned twice on average during the encounter to view the burn wound. It was initially positioned so the rater could see the patient's face and make introductions. Then the tablet was repositioned to view the burned area. Prior to the study's implementation, the need for additional lighting was explored. However, the use of additional lighting caused a glare on the tablet screen. In contrast, some researchers found it necessary to provide additional lighting or use a flash to improve the quality of the picture image (Murphy et al., 2006), while others did not find it necessary to provide an additional light source (Engel, et al., 2011; Braun, et al., 2005). In a study by Wofford et al. (2012), they found that the computer in the examination room should be positioned for adequate visualization of the patient and clinician prior to the encounter beginning. Wofford et al. (2012) also found that a special swiveling computer stand was necessary for adequate visualization. For this reason, the present study used a tablet device stabilizer to manipulate the tablet over the burn patient. Like the Wofford study, this study found it easy to use, minimizing tablet movement, and thereby minimizing image distortion.

**Patient Perceptions of Using a Tablet Device to Receive Burn Care**

Fifteen patients were interviewed on their perceptions of using the tablet device to receive burn care. Through this saturation of knowledge, several themes emerged through the patient interviews. Specifically, patients reported comfort and ease with using the tablet device, confidence in receiving burn care through the use of a tablet device, and overall patient

satisfaction. Similar themes emerged from the study by Vawdry et al. (2011) who reported that patients were very satisfied with their care and that use of the tablet device during their hospital stay would help them feel engaged in their care. Interestingly, over 80% of the patients in this study had some experience with use of a tablet device in their daily lives compared to Vawdry et al. (2011) who reported 80% of the patients had no experience with using a tablet prior to the study. This difference in exposure to using a tablet device is likely due to the proliferation of tablets over the past several years.

Another theme that emerged from this study was improved access to care. During the participant interviews, patients commented how access to the burn specialist to view the burn wound in between clinic visits or when the patient was concerned the burn wound didn't look right, would minimize the patient's stress, and allay anxiety and fear. Some participants recognized the potential of having their primary care physician use the tablet device to collaborate with the burn specialist to appropriately care for the burn. Other authors have suggested that telehealth in burn care would improve access to care (Myers et al., 2012; Nelson & Gingerich, 2010; Sayed-Abdul, Scholl, Chen, Santos, Jian, et al., 2012) and reduce hospital length of stay (Braun et al, 2005; Saffle et al., 2009; Sagraves et al., 2007; Wallace et al., 2008). Wallace et al. (2008) reported that fewer patients needed to return to the hospital for reassessment when the burn specialist employed medical decision-making based on an assessment of the burn from a digital image.

Although cost-savings were not evaluated, several patients commented on how use of the tablet device from home to care for the burn would lessen costs through reduced travel time and gas. Actual cost savings were reported by Nguyen, et al. (2004) who identified the average cost

for the patient to travel to a face-to-face visit was $166 per visit compared to telehealth travel cost of $20, equating to a $146 savings.

## Limitations

There are several limitations to this study that must be acknowledged. This study did not provide comprehensive burn care over time from the initial clinic visit to discharge from the clinic, therefore did not include scar evaluation or management. The study sample included few dark skinned individuals. Because it is more difficult to assess burn depth and surrounding erythema in dark skinned individuals, study findings should not be generalized to dark skinned individuals. Also, the telehealth encounter occurred during the usual clinic visit, not from the patient's home. Therefore, evaluation of patient perceptions of telehealth was compromised since the patient had to come in to the clinic for an evaluation compared to the convenience of receiving care from home.

There were five clinicians who participated in the study but only two Raters performing assessments at a time. Therefore, Rater 1 and Rater 2 were not always the same person. This variation in Raters allowed evaluation across a wider range of individuals thereby supporting generalization of findings. However, the raters had extensive burn experience (8 to 28 years) and these results can only be generalized to raters with similar burn experience. Results may reflect memory (recall) bias because the face-to-face assessment occurred within minutes of the tablet device assessment. The rater initially performed the Standard Burn Assessment through the tablet device. Within a few minutes, the rater entered the patient's examination room to perform the face-to-face examination and Standard Burn Assessment. The short time interval between assessments could have introduced bias into the study results. However, Smith, Kimble et al., (2004) found the degree of memory (recall) bias was less when the order of assessment

was tablet device followed by a face-to-face encounter relative to a face-to-face encounter followed by a tablet device. Patients who agreed to participate in the qualitative interview spent an additional 30 minutes in the clinic at the subsequent visit. The interview occurred in the examination room within a finite amount of time, as opposed to a time and room potentially more conducive to a therapeutic exchange of thoughts. Performing an interview while the clinic staff is seeing patients created some stress and potentially influenced the interview process.

The interpretation of the Kappa value requires recognition of the limitations associated with Cohen's Kappa. The Kappa statistic is influenced by the prevalence of the clinical finding which can affect the magnitude of the agreement (Sim & Wright, 2005). When prevalence of a given response is either very high or very low, the value of kappa may indicate a low level of reliability even when the observed proportion of agreement is high. For example, if the proportion of agreement between raters for a clinical finding (e.g. presence of rash, cellulitis, edema, or purulence) is greatly different from the proportion of disagreement of a clinical finding. This is because chance agreement is also high and the kappa statistic is reduced. In this study, rash and purulent drainage occurred infrequently. Therefore the proportion of agreement in the "no" response was high. Given how Cohen's kappa is calculated the Kappa value was artificially lowered. A secondary analysis of this data should include a calculation of Prevalence Adjusted Kappa (PAK) to determine if the prevalence impacted the Kappa value.

Based on the recommendations by Murphy et al. (2006), the predetermined acceptable kappa threshold for this study was set at 0.80. A Kappa value of 0.80 and higher indicates near perfect agreement and in the study by Murphy et al. (2006) near perfect agreement was found for the assessment of purulence, cellulitis, and edema. However, while a Kappa value of 0.80 may be appropriate for diagnostic purposes, others have established the reliability threshold with

Kappa values greater than 0.61 (substantial to near perfect reliability) (Braun et al., 2005; Jones et al., 2003; Tsai et al., 2008). Indeed, few Kappa values greater than 0.80 were found in the face-to-face comparisons. However it is well established that even in a face-to-face encounter, there is disagreement among providers on any given diagnosis. Therefore, study results were described by level of agreement rather than by threshold. Because this study involves small burn sizes (less than 10% total body surface area burned), total body surface area was not considered.

## Implications for Theory

The Behavioral Model of Health Services Use served as the framework for this study. One of the models constructs suggests that *population's characteristics* can influence one's *use of health services* thereby influencing individual *health outcomes*. The primary aim of this study and theoretical *outcome* was establishing the reliability and feasibility of using a tablet device to perform a standard burn assessment compared to the usual face-to-face encounter. An additional *outcome* was the feasibility of using a tablet to assess a burn wound and the patient's perception of tablet use to receive burn care. This study demonstrated feasibility of tablet use to assess a burn wound and reliability for assessing burn depth and skin graft take. Between modalities, cellulitis could be reliably assessed and, between raters, edema could be reliably assessed. Those interviewed implied that having additional options to receive health care can increase a person's tendency to access health care. All of the interview participants had a positive experience with use of the tablet to assess their burn wound and acknowledged acceptance to using the tablet device from home. Overall, patients indicated they might be satisfied with the use of a tablet device. Some participants had prior experience with using a tablet device and some recognized the utility of having their primary care physician use the tablet device to collaborate with the burn specialist to appropriately care for the burn. Although the patient's age, gender, race,

ethnicity and distance from the clinic were obtained, the effect of these *population characteristics* on use of a tablet device to receive burn care was not measured. In addition, *health behavior* consisted of patients with a burn injury seeking initial care in an outpatient burn clinic. In this study, the average burn size was less than 2% total body surface area burned. However, patients with burn injuries less than 10% total body surface area can be treated in an outpatient burn clinic. It has not been established if patient's with larger burn sizes (> 8% total body surface area burned) could be adequately assessed using the tablet device.

## Implications for Practice

The tablet device provides real-time interactive video. Unlike the traditional store-and-forward technology, the tablet device allows patients and providers to participate in a virtual consultation. In an era of diminished verified burn centers and compromised access to burn care, burn specialists can collaborate with distant providers to guide clinical decision-making and provide feedback. Results from this study provide beginning support for the reliability of using a tablet device for burn care. Although all the patients interviewed were comfortable with using the tablet device from home to receive burn care, the patients wanted the initial burn evaluation to occur face-to-face. So, an ideal telehealth protocol in burn care would include the initial consultation occurring face-to-face in the burn clinic, followed by weekly telehealth consultations from home, and if necessary, telehealth consultations occurring on an as needed basis. Using a tablet device from home, communication between a burn patient and burn provider could identify burn–related complications and initiate treatment earlier, address patient concerns, and allay anxiety.

There is some inconsistency in the reliability of the tablet device to assess for cellulitis and edema. In the future, a panoramic view of the burn area, surrounding extremity and

contralateral extremity is necessary for a comparative and thorough assessment. The most critical variables in assessing a burn patient are burn depth, total body surface area burned, and cellulitis. Because of the decline in verified burn center, providers not skilled in burn care are confronted with evaluating burn patients. Through telehealth, rural and non-burn care providers could collaborate with the regional burn specialist to determine burn depth and if grafted, graft take. Given there was little difference between the face-to-face and tablet device assessments, findings suggest the burn specialist can also collaborate with the remote provider to determine if the burn wound has surrounding cellulitis indicating infection and provide direction for the initial care, arrange for appropriate transfer to the burn facility if needed, or arrange follow-up in the outpatient burn clinic. Burn care specialists could implement use of a tablet device to provide continuity of care for patients who live a distance from the clinic. Through a tablet device, with a high resolution camera, signs of cellulitis and purulence on the dressing could direct a plan of care to include initiation of antibiotics, a change in the dressing selection, direct the patient to return to the clinic for further evaluation and treatment. Use of telehealth services in burn care could bridge the knowledge gap between burn specialists and surrounding health care providers and patients.

## Recommendations for Future Research

The reliability of using a tablet device to assess *each* component of the Standard Burn Assessment was not fully established, specifically for purulence, edema, and rash. Further research with a better tablet, a newer iPAD© model, may produce a better quality image and impact the findings of the study. Future research should establish the reliability of using a tablet device to assess burn sizes greater than 10% total body surface area. This could be established with surrounding emergency room physicians using a tablet device to consult with a burn

specialist regarding initial burn care to determine if the patient needs to be admitted versus being seen in the outpatient burn clinic. Furthermore, a telehealth consultation between an emergency room physician and the burn specialist can help determine if the patient needs to air transport to the burn facility, ambulance, or car transport.

Future studies should calculate burn depth as a weighted Kappa statistic. Additional research is necessary to further examine which components of the Standard Burn Assessment are useful and reliable in assessing burn wounds and delineate which components (purulence, edema, and rash) are not reliable. Additional future analysis should include calculation of the Prevalence Adjusted Kappa (PAK) to determine which variables may have an artificially low kappa value due to a low prevalence of a particular clinical finding. Because only small burn injuries were included in this study, total body surface area was not assessed between raters but should be in future burn studies.

Population characteristics (patient's age, gender, race, and distance from the clinic) should be further explored to determine which population characteristics increase one's propensity to utilize telehealth services. Further exploration of the population characteristics on patient satisfaction is necessary and could provide insight into one's propensity to utilize telehealth services. Patient perception of tablet use and satisfaction should be measured using a valid tool, such as the Telemedicine Satisfaction and Usefulness Questionnaire.

## Conclusion

Results from this study provide beginning support for the reliability of using a tablet device for burn assessment specifically when the burn depth is full-thickness and to assess skin graft take and burn depth. Findings suggest inconsistency in the reliability of a tablet device to assess for the presence of cellulitis, edema and purulence. When evaluating the overall

reliability of assessing a burn wound, the tablet device was similar to a face-to-face examination but varied depending on the depth of the burn injury. The highest correlations were found when assessing a deep partial thickness burn wound. Despite the variation in agreement with specific components of the Standard Burn Assessment, nearly every rater stated each of the Standard Burn Assessment components could be adequately visualized through use of the tablet device. Patients were largely satisfied with the use of a tablet device to receive their burn care. At a fraction of the cost of traditional interactive tele-videoconferencing equipment, the tablet device provides real-time interaction between providers and patients. Tablet device use in burn care can augment the usual, standard face-to-face interaction between patient and provider. Continued research is necessary to further validate its use in early and accurate diagnosis of burn depth, burn-related complications, the evaluation of graft take, and although not assessed in this study, the development of hypertrophic scarring.

# References

Aday, L.A. & Andersen, R. M. (1974). A framework for the study of access to medical care. *Health Service Research, 9,* 208-220.

American Burn Association. (2005). *American Burn Association*. Retrieved from http://www.ameriburn.org/resources_factsheet.php

American Burn Association. (2009). American Burn Association *White Paper on Surgical Management of the Burn Wound and Use of Skin Substitutes* [White paper]. Retrieved from *www.ameriburn.org/**WhitePaper**Final.pdf*

American College of Surgeons, Committee on Trauma. "Guidelines for the Operation of Burn Centers." In *Resources for Optimal Care of the Injured Patient,* 2006; 14: 79-86.

Andersen, R. M. (1995). Revisiting the behavioral model and access to medical care: does it matter? *Journal of Health and Social Behavior, 36,* 1-10.

Andersen, R. M. & Davidson, P.L. (1995). Improving access to care in America: individual and contextual indicators. In R. Andersen, T. Rice, & G. Kominsky (Eds), *Changing the US Health Care System.* (pp. 3-31). San Francisco, Ca: Jossey Bass.

"As Global Telemedicine Market Surges Past $2.5 Billion, Markets for Telehealth Servers and Equipment Are Expected to Rise in Tandem." *As Global Telemedicine Market Surges Past $2.5 Billion, Markets for Telehealth Servers...* N.p., n.d. Web. 29 Nov. 2013. (http://www.prnewswire.com/news-releases/as-global-telemedicine-market-surges-past-25-billion-markets-for-telehealth-servers-and-equipment-are-expected-to-rise-in-tandem-184156821.html).

Bittorf, A., Fartasch, M., Schuler, G., & Diepgen, T.L. (1997). Resolution requirements for digital images in dermatology. *Journal of American Academy of Dermatology,* 37, 195-198.

Braun, R., Vecchietti, J., Thomas, L., Prins, C., French, L., Gewirtzman, A., Saurat, J., & Salomon, D. (2005). Telemedical wound care using a new generation of mobile phones: A feasibility study. *Archives of Dermatology,* 141, 254-258.

Chanussot-Deprez, C., & Contreras-Ruiz, J. (2008). Telemedicine in wound care. *Journal of International Wounds,* 5, 651-655.Church, D., Elsayed, S., Reid, O., Winston, B., & Lindsay, R. (2006). Burn wound infections. *Clinical microbiology reviews*, *19*(2), 403-434.

Creswell, J. W., & Clark, V. L. P. (2007). *Designing and conducting mixed methods research*. Thousand Oaks, CA: Sage publications.

DeSanti, L. (2005). Pathophysiology and current management of burn injury. *Advancements in Skin Wound Care,* 18, 323-332.

Donner A, & Eliasziw M. (1992). A goodness-of-fit approach to inference procedures for the kappa statistic: confidence interval construction, significance-testing and sample size estimation. Stat Med. Aug: 11 (11):1511-9.

Engel, H., Huang, J., Tsao, C., Lin, C., Chau, P., et al. (2011). Remote real-time monitoring of free flaps via smartphone photography and 3G wireless internet: A prospective study evidencing diagnostic accuracy. *Microsurgery,* 31, 589-595.

Galdino, G. M., Vogel, J. E., & Vander Kolk, C. A. (2001). Standardizing digital photography: it's not all in the eye of the beholder. *Plastic and reconstructive surgery, 108*(5), 1334-1344.

Gamm, L., Castillo, G., & Pittman, S. (2010). Access to quality health services in rural areas-primary care: A literature review. *LD Gamm, LL Hutchinson, BJ Dabney, BJ and AM Dorsey (Eds.), Rural healthy people*.

Gibran, N.S. & Hiembach, D.M. (2000). Current status of burn wound pathophysiology. *Burn Care and Management,* 27 (1), 11-22.

Gomez, R., & Cancio, L.C. (2007). Management of burn wounds in the emergency department. *Emergency Medicine Clinics of North America,* 25, 135-146.

Graneheim, U. H., & Lundman, B. (2004). Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness. *Nurse education today*, *24*(2), 105-112.

Gregg W, Moscovice I. 2003. The evolution of rural health networks: Implications for health care managers. *Health Care Management Review* 28(2):161–177.

Guagliardo, M.F., Jeng, J.C., Browning, S., Bilodeau, M., Dimich, A., Hickerson, W., Miller, S., & Peck, M. (2008). Admissions across state lines: Harnessing the insight of the National Burn Repository for the healthcare accessibility, fiscal, and legislative concerns facing the American Burn Association. *Journal of Burn Care and Research*, 29, 151-157.

Haley, S. M., & Osberg, J. S. (1989). Kappa coefficient calculation using multiple ratings per subject: a special communication. *Physical Therapy*, *69*(11), 970-974.

Hartford, C.E. & Kealey, G.P. (2007). Care of outpatient burns. In D.N. Herndon & J.H. Jones (eds). *Total Burn Care (*67-80), Philadelphia, PA: WB Saunders.

Holt, B., Faraklas, I., Theurer, L., Cochran, A., & Saffle, J. (2012). Telemedicine use among burn centers in the U.S.: A survey. *Journal of Burn Care and Research*, 33, 157-162.

Hsieh, C., Tsai, H., Yin, J., Chen, C., Yang, J., & Jeng, S. (2004). Teleconsultation with the mobile camera-phone in digital soft tissue injury: A feasibility study. *Plastic and Reconstructive Surgery,* 114, 1776-1782.

Institute of Medicine. (2001). Crossing the quality chasm: A new health system for the 21st century; Brief Report. Washington, D.C: National Academies Press. Retrieved from http://www.nap.edu/openbook.php?isbn=0309072808 .

Institute of Medicine (2012). The role of telehealth in an evolving health care environment: Workshop Summary. Washington, D.C.: National Academies Press.

Johansen, M.A., Wootten, R., Kimble, R., Mill, J., Smith, A., & Hockey, A. (2004). A feasibility study of email communication between the patient's family and the specialist burn team. *Journal of Telemedicine and Telecare, 10,* 53-56.

Johnson, R.M., & Richard, R. (2003). Partial-thickness burns: Identification and management. *Advances in Skin and Wound Care,* 16(4), 178-185.

Jones, S.M., Banwell, P.E., & Shakespeare, P.G. (2004). Telemedicine in wound healing. *International Wound Journal,* 4(1), 225-230.

Jones, O.C., Wilson, D.I., & Andrews, S. (2003). The reliability of digital images when used to assess burns. *Journal of Telemedicine and Telecare,* 9 (Supp. 1), S1:22-24.

Kao, C.C. & Garner, W.L. (2000). Acute burns. *Plastic and Reconstructive Surgery,* 101(7), 2482-2492.

Klein, M.B., Kramer, C.B., Nelson, J., Rivera, F.P., Gibran, N.S., & Concannon, T. (2009). Geographic access to burn center hospitals. *Journal of the American Medical Association,* 302(16), 1774-1781.

Klein, M.B., Nathens, A.B., Emerson, D., Heimbach, D.M., & Gibran, N.C. (2007). An analysis of the long distance transport of burn patients to a regional burn center. *Journal of Burn Care and Research,* 28, 49-55.

Kobza, L., & Schuerich, A. (2000). The impact of telemedicine on outcomes of chronic wounds in the home care setting. *Ostomy Wound Management,* 46(10), 48-53.

Kraemer, H.C., Periyakoil, V.S., & Noda, A. (2004). Tutorial in biostatistics: Kappa coeffeicients in medical research. *Tutorials in Biostatistics Volume 1: Statistical Methods in Clinical Studies.* John Wiley and Sons, *85-105.*

Krippendorff, K. (2011). Agreement and information in the reliability of coding. *Communication Methods and Measures,* 5 (2), 1-20. http://repository.upenn.edu/cgi/viewcontent.cgi?article=1286&context=asc_papers.

Kwet, K.L. (2012). Handbook of Inter-rater Reliability Third edition The definitve guide to measuring the extent of agreement among multiple raters

Leech, N. L., & Barrett, K. C. Morgan. GA (2008). *SPSS for intermediate statistics: Use and interpretation*.

Litzinger, G., Rossman, T., Demuth, B., & Robets, J. (2007). In-home wound care management utilizing information technology. *Home Healthcare Nurse, 25,* 119-130.

Maheu, M., Whitten, P., and Allen, A. (2001). History, Definitions, and Current Applications. *E-Health, Telehealth, and Telemedicine: a Guide to Start-up and Success*. (pp. 1-3). San Francisco: Jossey-Bass.

Marshall, C., & Rossman, G. B. (2010). *Designing qualitative research*. Sage.

Moore, L. (2008). Letter to the editor: WOCN membership. *Journal of Wound, Ostomy, Continence Nursing,* 35(3), 267.

Moss, L.S. (2004). Outpatient management of the burn patient. *Critical Care Nursing Clinics of North America,* 16, 109-117.

Murphy, R.X., Bain, M.A., Wasser, T.E., Wilson, E., Okunski, W.J. (2006). The reliability of digital imaging in the remote assessment of wounds. *Annals of Plastic surgery*, 56, 431-436.

Myers, L., Gibbs, D., Thacker, M., & Lafile, L. (2012). Building a telehealth network through collaboration: The story of the Nebraska statewide telehealth network. *Critical Care Nursing Quarterly,* 35(4), 346-352.

Nelson, J. A., & Gingerich, B. S. (2010). Rural health: Access to care and services. *Home Health Care Management & Practice*, *22*(5), 339-343.

Nesbitt, T. S., Hilty, D. M., Kuenneth, C. A., & Siefkin, A. (2000). Development of a telemedicine program: A review of a 1000 video-conferencing consultations. *World Journal of Medicine, 173*, 169-174.

Nguyen, L.T., Massman, N. J., Franzen, B.J., Ahrenholz, D.H, Sorensen, N.W., Mohr, W. J., et al. (2004). Telemedicine Follow-up of Burns: Lessons Learned from the First Thousand Visits. *Journal of Burn Care and Rehabilitation*, 485-490.

Pirris, S.M., Monaco, E.A., & Tyler-Kabara, E.C. (2010). Telemedicine through the use of digital cell phone technology in pediatric neurosurgery: A case series. *Neurosurgery, 66, 9*99-1004.

Polit, D. F, & Hungler, B., P. (1999). *Nursing research: Principles and methods, 6.*

Pruitt Jr, B. A., McManus, A. T., Kim, S. H., & Goodwin, C. W. (1998). Burn wound infections: current status. *World journal of surgery*, *22*(2), 135-145.

Redlick, F. M., Roston, B. M., Gomez, M. M.., & Fish, J. S. (2002). An initial experience with telemedicine in follow-up burn Care. *Journal of Burn Care and Rehabilitation, 23,* 110-115.

Roa, L., Gomez-Cia, T., Acha, B., & Serrano, C. (1999). Digital imaging in remote diagnosis of burns. *Burns, 25,* 617-6.

Rosenblatt, R. A., Andrilla, C. H. A., Curtin, T., & Hart, L. G. (2006). Shortages of medical personnel at community health centers. *JAMA: the journal of the American Medical Association*, *295*(9), 1042-1049.

Roth, A.C., Reid, J.C., Puckett, C.L., & Concannon, M.J. (1999). Digital images in the diagnosis of wound healing problems *Plastic and Reconstructive Surgery,* 103: 483- 486.

Saffle, J.R., Edelman, L.P., Theurer, L.B., Morris, S.E., & Cochran, A. (2009). Telemedicine evaluation of acute burns is accurate and cost-effective. *Journal of Trauma: Injury Infection & Critical Care, 67,* 358-365.

Sagraves, S.G., Phade, S.V., Spain, T., Bard, R., Goettler, C.E., & Schenarts, P.J. (2007). A collaborative systems approach to rural burn care. *Journal of Burn Care and Research, 28*, 111-114.

Sargent, R.L. (2006). Management of blisters in the partial-thickness burn: An integrated research review. *Journal of Burn Care and Research,* 27, 66-81.

Shokrollahi, K., Sayed, M., Dickson, W., & Potokar, T. (2007). Mobile phones for the assessment of burns: We have the technology. *Emergency Medicine Journal*, 24, 753-755.

Sim, J., & Wright, C. C. (2005). The kappa statistic in reliability studies: use, interpretation, and sample size requirements. *Physical therapy*, *85*(3), 257-268.

Sitts, M.K. Handbook for Digital Projects: A Management Tool for Preservation and Access, ed. Andover, MA: Northeast Document Conservation Center, 2000.

Smith, A. C., Kimble, R., Mill, J., Bailey, D., O'Rourke, P., & Wootton, R. (2004). Diagnostic accuracy of and patient satisfaction with telemedicine for the follow-up of paediatric burns patients. *Journal of telemedicine and telecare*, *10*(4), 193-198.

Smith, A. C., Youngberry, K., Mill, J., Kimble, R., & Wootton, R. (2004). A review of 3 years experience using email and videoconferencing for the delivery of post-acute burns care to children in Queensland. *Burns, 30*, 248-252.

Tablet Device is Poised to Revolutionize Telemedicine. In *Facebook* (CareHQ Page). Retrieved on November 29, 2013, from https://www.facebook.com/media/set/?set=a.400996886609548.89725.309235792452325

Terry, M., Halstead, L.S., O'Hare, P., Gaskill, C., & Ho., P.S. et al. (2009). Feasibility study of home care wound management using telemedicine. *Advances in Skin and Wound Care*, 22(8), 358-364.

Turk, E., Karagulle, E., Aydogan, C., Oguz, H., Tarim, A., Karakayali, Haberal, M. (2011). Use of telemedicine and telephone consultation in decision-making and follow-up of burn patients: Initial experience from two burn units. *Burns,* 37, 415-419.

Tsai, H., Pong, Y., Liang, C., Lin, P., & Hsieh, C. (2004). Teleconsultation by using the mobile camera phone for remote management of the extremity wound: A pilot study. *Annals of Plastic Surgery*, 53(6), 584-587.

van Teijlingen, E., & Hundley, V. (2001). The importance of pilot studies. *Social research update*, (35), 1-4.

Vawdrey D. K., Wilcox L.G., Collins S.A., Bakken, S., Feiner, S., Boyer, A., & Restaino S.W. (2011). A tablet computer application for patients to participate in their hospital care. AMIA Annu Symp Proc; AMIA 2011 Annual Symposium - Improving Health: Informatics and IT Changing the World; October 22-26, 2011; Washington DC. 2011. pp. 1428–35. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3243172/.

Viera, A.,J. & Garrett, J.M. (2005). Understanding interobserver agreement: The Kappa statistic. *Family Medicine,* 37(5), 360-363.

Wallace, D.L., Hussain, A., Kahn, N., and Wilson, Y.T. (2012). A systematic review of the evidence for telemedicine in burn care: With a UK perspective. *Burns,* 38, 465-480.

Wallace, D. L., Jones, S. M., Milroy, C., & Pickford, M. A. (2008). Telemedicine for acute plastic surgical trauma and burns. *Journal of Plastic, Reconstructive & Aesthetic Surgery, 61*(1), 31-36. doi: DOI: 10.1016/j.bjps.2006.03.045

Wofford, J.L., Campos, C.L., Johnson, D.A., & Brown, M.T. (2012). Providing a Spanish interpreter using low-cost videoconferencing in a community health center: a pilot study using tablet computers. *Informatics in Primary Care,* 20, 141-146.

# APPENDIX A. PATIENT DEMOGRAPHIC INFORMATION, HISTORY OF PRESENT ILLNESS, PAST MEDICAL HISTORY, SOCIAL HISTORY

Appendix A
Patient Demographic Form
Subject number: _____

| | |
|---|---|
| Age (in years) | |
| Gender | Male ☐ Female ☐ |
| Ethnicity (circle) | Hispanic<br>Non-hispanic |
| Race (circle) | White/Caucasian<br>American Indian or Alaska Native<br>Asian<br>Black<br>Native Hawaiian or Other Pacific Islander |
| Date of injury | mm/dd/yyyy |
| Mechanism of injury (circle one) | Scald<br>Grease<br>Flame<br>Chemical<br>Electric<br>Thermal/Contact |
| Location of Burn (circle all that apply) | Neck (anterior/posterior)<br>Upper arm (left/right)<br>Forearm (left/right)<br>Wrist (left/right)<br>Hand- (left/right)<br>Chest<br>Abdomen,<br>Shoulder (left/right)<br>Upper back (left/right)<br>Lower back (left/right)<br>Thigh (left/right)<br>Lower leg (left/right)<br>Foot (left/right) |
| TBSA | <1%, 1%, 2%, 3%, 4%, 5%,<br>6%, 7%, 8%, 9%, 10% |
| Distance from Home to Clinic (in miles) | |
| Number of Times Tablet Device Repositioned by **First Rater**<br>Number of Technical Difficulties and Description | |
| Number of Times Tablet Device Repositioned by **Second Rater**<br>Number of Technical Difficulties and Description | |

## APPENDIX B. STANDARD BURN ASSESSMENT FORM

# Appendix B

Standard Burn Assessment and Feasibility
Subject number_____
Face-to-Face or Tablet Device (Circle One)
First Rater or Second Rater (Circle One)
Clinician 1, Clinician 2, Clinician 3, Clinician 4 or Clinician 5 (Circle One)

| OUTCOME VARIABLES | OPERATIONAL DEFINITION | LEVEL OF MEASUREMENT |
|---|---|---|
| **Burn Depth**<br><br>Superficial<br><br>Partial thickness<br><br>Deep-Partial<br><br>Full thickness | Epidermis lost, minimal damage to dermis, red/wet bed, blisters<br><br>Pale pink wound bed, deeper damage to dermis, loss of some appendages<br><br>Complete loss of epidermis, dermis and appendages, pale/leathery bed | **Categorical/Nominal**:<br>Superficial (1)<br>Partial thickness<br><br>Deep-Partial (2)<br><br>Full thickness (3)<br><br>NA/skin graft (99) |
| **Burn Depth: Adequate Visualization for Assessment and Clinical Decision-Making**<br><br>**If no, Comment:** | | Yes (1)<br>No (0)<br>NA/skin graft (99) |
| **Purulent Drainage**<br><br>**Purulent Drainage: Adequate Visualization for Assessment and Clinical Decision-Making**<br><br>**If no, Comment:** | Yellow, tan, or green wound fluid/exudate present on the wound bed and wound dressing | **Categorical/Nominal:**<br>Yes (1)<br>No (0)<br>Yes (1)<br>No (0) |
| **Periwound Rash**<br><br>**Periwound Rash: Adequate Visualization for Assessment and Clinical Decision-Making**<br><br>**If no, Comment:** | Erythematous papules, pustules, milia, or excoriated/denuded skin around the burn wound | **Categorical/Nominal:**<br>Yes (1)<br>No (0)<br><br>Yes (1)<br>No (0) |

Appendix B continued
Subject number_____
Standard Burn Assessment and Feasibility
Face-to-Face or Tablet Device (Circle One)
First Rater or Second Rater (Circle One)
Clinician 1, Clinician 2, Clinician 3, Clinician 4 or Clinician 5 (Circle One)

| OUTCOME VARIABLES | OPERATIONAL DEFINITION | LEVEL OF MEASUREMENT Categorical/Nominal | |
|---|---|---|---|
| **Presence of Cellulitis** | Erythema, warmth, localized pain, tenderness, edema of the skin around the burn wound | **Dichotomous:** Yes<br>No | (1)<br>(0) |
| **Presence of Cellulitis: Adequate Visualization for Assessment and clinical Decision-making**<br><br>**If no, Comment:** | | Yes<br>No | (1)<br>(0) |
| **Presence of Edema** | Increased interstitial fluid in the tissues of the affected burn area, observed swelling of the tissue surrounding the burn wound area | Yes<br>No | (1)<br>(0) |
| **Presence of Edema: Adequate Visualization for Assessment and Clinical Decision-making**<br><br>**If no, Comment:** | | Yes<br>No | (1)<br>(0) |
| **Skin Graft Take** | Greater than 90% graft adherence | Yes<br>No<br>NA/Skin graft | (1)<br>(0)<br>(99) |
| **Skin Graft Take: Adequate Visualization for Assessment and clinical decision-making**<br><br>**If no, Comment:** | | Yes<br>No<br>NA/Skin graft | (1)<br>(0)<br>(99) |

# APPENDIX C. QUALITATIVE INTERVIEW QUESTIONS

Appendix C
Telehealth Qualitative Interview
Subject number: _____

1. Have you had any experience with operating or using a tablet device in the past?

   a. If yes, describe your past experiences.

2. After you had the experience with the tablet device in the clinic today, tell me what it was like speaking to the physician through the tablet? Describe how the physician examined your burn using the tablet.

**I would like for you to think about using a tablet device from home like you saw us using the tablet device in the clinic.**

3. Do you think you would be able to use the tablet device for letting the provider check on and see your burn?

4. In the future, if we give you a tablet device to take home, would you be agreeable to having your burn looked at by the physicians and nurses using the tablet device?
   if no can you talk about why you would not?

   If yes, can you talk about why you would?

   If yes, how many weeks do you think it best to use the tablet appointments from home before coming into the clinic?

5. Please compare the advantages and disadvantages of using the tablet from home versus driving from your home to the clinic for your burn care?

Appendix C
Telehealth Qualitative Interview
Subject number: _____

6. How confident are you that you will receive the same standard of burn care using the tablet device as you would at the clinic?

7. What concerns or other comments do you have about using a tablet device from home to receive burn care?

# APPENDIX D: SCRIPTED TELEPHONE STUDY INTRODUCTION

Appendix D

Scripted Telephone Study Introduction

I am informing each new burn patient that we are conducting a study in the clinic. The purpose of the study is to evaluate the use of a tablet device, the XOOM, to assess burn wounds. You will be provided information about the study at your first scheduled clinic visit. However, if you have questions about this study that you would like answered before your clinic visit, you may contact the study nurse researcher, Suzanne Mitchell. Her phone number is 913-588-4238. Please leave a message and she will return your call.

# APPENDIX E. TELEHEALTH STUDY INFORMATION SHEET

Appendix E
Telehealth Study Information Sheet
Subject number: _____

Hello,

Suzanne Mitchell, a nursing PhD student and burn clinic nurse practitioner, is conducting a study at the University of Kansas Hospital Outpatient Burn and Wound Care Clinic to evaluate the use of a tablet device, the **XOOM tablet**, to assess burn wounds. Patients agreeing to participate in this study will have the usual burn care with a burn specialist caring for you in the examination room. For the study, two other burn specialists will be viewing your burn wounds while you are in the clinic. These two burn specialists will first view your burn using the **XOOM tablet**. Then, they will come into the examination room to view your burn in-person. If you would like to participate in the study, you may choose to participate during your first clinic visit or during your second clinic visit.

If you are interested in learning more about the study, mark with an **"X"** below and Suzanne Mitchell will discuss the study in more detail in the examination room after you have received care for your burn. There are no additional fees associated with this study.

Thank you for your consideration.

I am interested in learning more about this study. 

I am NOT interested in learning more about this study 

# APPENDIX F: PROTOCOL FOR CLEANING TABLET DEVICE

Appendix F
Protocol for Cleaning Tablet Device at University of Kansas Hospital

When a single tablet device is being used by multiple people either in a home, clinic or another setting you may wish to disinfect the parts of the tablet device that people come into contact with, such as the the tablet device, stablizing arm, and table.

In order to properly disinfect these areas, you should use Lysol Wipes or Clorox Kitchen Disinfecting wipes and follow the general rules below when disinfecting your tablet device and stabilizing equipment. **Note**: Do not use excessively damp cleaning wipes. You may need to squeeze the wipe to remove any excess dampness.

**Do's**

- Be sure to turn off your tablet device and remove the battery from portables or wireless keyboards and mice, before you start the cleaning process.
- Use a disinfectant wipe to wipe the area first, then use a damp, soft, lint-free cloth, and finally dry the area with another soft, lint-free cloth.
- Replace the screen saver film.
- Be sure to remove and disinfect all surfaces of the protective case with Lysol Wipes or Clorox Kitchen disinfecting wipes.

**Don'ts**

- **Do not** use disinfectant wipes containing bleach or disinfectant sprays in general.
- **Do not** use an extremely damp disinfectant wipe to clean the area. If you encounter a very damp wipe it may need to be squeezed to remove some of the excess liquid before use.
- **Do not** allow the liquid from the disinfectant wipe to sit or pool on the area being disinfected for a long amount of time.
- **Do not** use rough towels or cloths to dry the area.

(Personnel Communication) Dedrick Hooper, University of Kansas Telemedicine Systems Coordinator, January 10, 2014.