



Research Article

Implementing Technology in Practice: Factors Associated with Clinicians' Satisfaction with an AI Wound Assessment Solution

Heba Tallah Mohammed^{1*}, Amy Cassata¹, Robert D. J. Fraser^{1,2}, David Mannion¹

¹Swift Medical Inc., Toronto, ON, Canada

²Arthur Labatt Family School of Nursing, Western University, London, ON, Canada

*Corresponding author: Heba Tallah Mohammed, Swift Medical Inc., Toronto, ON, Canada

Citation: Mohammed HT, Cassata A, Fraser RDJ, Mannion D (2023) Implementing Technology in Practice: Factors Associated with Clinicians' Satisfaction with an AI Wound Assessment Solution. Int J Nurs Health Care Res 6:1452. DOI: <https://doi.org/10.29011/2688-9501.101452>

Received Date: 17 July, 2023; **Accepted Date:** 24 July, 2023; **Published Date:** 28 July, 2023

Abstract

Introduction: A digital wound care management application (Swift) leveraging Artificial Intelligence (AI) technology is used by healthcare providers to improve the quality of wound care. **Methods:** Our observational cross-sectional study invited clinicians using Swift to evaluate wounds at their practice to participate in an online survey to assess their practice patterns, overall satisfaction with the solution, and perspectives on the perceived benefits of using it through a five-point Likert scale and open-ended questions. **Results:** Overall, our study recorded 81% satisfaction among clinicians. Our findings noted a significantly higher satisfaction (85.5% vs. 76.5%, $P=0.034$) and agreement on perceived clinical benefits, such as tracking clinical changes in wounds (88.7% vs. 83.6%, $P=0.045$), saving time in assessing wounds (81.1% vs. 71.6%, $P=0.023$), and effective collaboration (76.1% vs. 70.4%, $P=0.044$), among those who used the solution for more than nine months compared to those who used the solution for less than nine months. Using the logistic regression model, the likelihood of clinicians' satisfaction with the technology increased two-fold with the prolonged use of the technology (OR 2.334, 95% CI 1.940- 5.792, $P=0.042$) and when the solution was seen to enable more efficient collaboration (OR 2.291, 95% CI 2.928-5.656, $P=0.047$). **Conclusion:** Clinician satisfaction with technology changes over time. Therefore, it is essential when implementing a new technology to investigate its ability to meet clinical needs and improve the user experience. A holistic understanding of what drives clinician satisfaction in practice is essential.

Keywords: Artificial intelligence; Wound care; Technology, User experience; Length of use

Introduction

For efficient wound management, healthcare providers are required to conduct a comprehensive wound assessment, which encompasses precise wound measurements, detailed documentation, and ongoing monitoring [1]. However, this can

often be challenging [1,2] as the traditional, manual methods of completing wound assessments, in many cases, are unreliable, time-consuming, and can lead to poor care quality [3-7]. Further, with the scarcity of systematic wound care approach-many guidelines are consensus-based and lack strong evidence [2,8] there is a high degree of variability in wound care assessments and documentation [9,10], which negatively influences the quality of wound care diagnosis and management [2,8]. Ousey and colleagues reported in their survey study that clinicians were cognisant of existing

frameworks for wound bed assessment; however, only 60% used them and did so in variable ways [11]. Another study surveyed 120 nurses working in an acute care facility in a large metropolitan hospital, where 71 nurses reported limited knowledge of the wound management national guidelines [12]. Therefore, with the increase in complex chronic wound prevalence [8], inadequate staffing levels, limited education, and limited wound care experts, standardized, efficient wound management is subject to even more significant challenges [13].

These contextual impediments contribute to high levels of clinical variability in wound care that impact operational care delivery, access to wound care, and healing outcomes. These challenges are exacerbated by the global shortage of nurses in clinical practices [14]. Evidence shows that this crisis is based on poor working conditions for nurses including poor planning and allocation of resources, unsatisfactory recruitment and retention policies, and ineffective utilization of qualifications and skills. This crisis has a dire impact on healthcare delivery and outcomes [14]. Therefore, at the organizational level, decision-makers are focused on maximizing clinical efficiencies, practice capacity, and increasing nurse retention to facilitate equitable care [15]. Evidence shows that organizational interventions to improve clinical efficiency and work conditions for clinicians should encompass efforts to improve job resources - such as documentation tools, clinical decision supports, and automated alerts - while minimizing job demands [16]. Thus, organizations appreciate that to provide accessible, equitable, and quality care, they must ensure their clinical staff is satisfied and retained with technologies and tools that support efficiency, documentation, and decision support, which significantly improve clinicians' working conditions.

Therefore, in recent years, considerable efforts have been spent on procuring and implementing digital technologies across the healthcare system to enhance staff productivity, clinical efficiency, and quality of care [17]. For example, a US-based hospital outpatient clinic study reported about a 30% reduction in chargeable expenditures per patient visit following the integration of a point-of-care digital wound management solution within its system [18].

Therefore, to address the challenges with wound assessment and management in healthcare and to support organizational efforts to maximize productivity and minimize costs, Swift Medical's technology has been adopted various healthcare facilities in the US and Canada. The solution is embraced as a supportive tool to improve the quality and efficiency of wound care by empowering healthcare professionals to easily capture, share and analyze accurate wound data at the point-of-care, enhancing treatment decision-making and clinical outcomes.

Swift Medical's solution utilizes Artificial Intelligence (AI) to enable the capture of high-quality images and automatically calculate high precision wound measurements in a fraction of the time it takes through traditional, manual methods [4,19]. The application integrates with the Electronic Medical Record (EMR) system, providing clinicians with comprehensive views of wound healing and patient risk. Moreover, this technology supports virtual collaboration between bedside clinicians and remote specialists to enable enhanced treatment decisions.

Investigating user satisfaction and perceived attitudes toward emerging digital technologies has been the focus of many researchers for decades, and the evolution of the applied models and theories is tangible [20,21]. Many theories have been presented to apprehend the attitude and intention toward adopting and using the technology. The widely used theories in health informatics are the Technology Acceptance Model (TAM), the Unified Theory of Acceptance and Use of Technology (UTAUT), and the Unified Theory of Acceptance and Use of Technology (UTAUT2) [17,22]. In general, acceptance of technology can be predicted by the perceived usefulness and perceived ease of use [23,24,25], while adopting the technology depends on effort and performance expectancy, social influences, and availability of supportive infrastructure [17,23] with age, gender, experience, and ability to use the tool voluntarily as moderators [24].

To our knowledge, there are limited publications about clinician satisfaction with electronic wound assessment technology and the intention to adopt it. With the high rates of clinician burnout and attrition across healthcare, creating an even more strained healthcare system, understanding satisfaction with new technology and tools designed to improve their work conditions is more critical now than ever. As the technology, adoption level is vastly dependent on the users' satisfaction level with the technology and its usefulness [23], there is a need to get insight into contingent factors that facilitate the satisfaction and adoption of wound care assessment technology.

Therefore, this study sought to explore clinicians' level of satisfaction and perception of the technology's clinical benefits. In addition, the study sought to explore the relationship between users' practice patterns and perceived benefits and satisfaction of the solution. Finally, the study assessed the predictive factors associated with clinicians' satisfaction with the digital solution.

Materials and Methods

Study design and population

This is a quality improvement descriptive cross-sectional survey of clinicians currently evaluating wounds using the Swift Medical application.

The study population consisted of active certified wound care clinicians in the US who have been using the application to evaluate wounds. Using the readily available data in the Swift application, of the thousands of wound care clinicians using Swift in the US, about 2,000 clinicians practicing in multiple care settings (i.e., home health care, outpatient clinics, and hospitals) across the US expressed an interest in participating in surveys or benefits evaluation studies upon initial adoption or renewal of the application.

On June 21st, 2022, 2000 email invites with survey links were sent, either directly or through the administration at the participating organization. This represents over 100 Home Health Agencies (HHA), hospitals, and clinics across the US. Clinicians were encouraged to share the survey link with their networks who were eligible to participate in the study. The survey link directed the users to the Survey Monkey platform - an online survey tool to collect anonymous responses.

The survey link remained active for 13 days from June 21st till midnight on July 3rd, 2022. A reminder email was sent on June 28th, 2022, to the available list of clinicians' email addresses who adopted the technology; one week after the initial invite. A second and final reminder was sent on June 30th, 2022, before the survey closing date.

Sample size calculation indicated that with a population size of 2000 and the study's alpha level set at 0.05 for an 80.0% power, responses from 323 clinicians are required to detect significant differences in data if one exists.

The survey was designed for self-completion by clinicians currently using the wound management solution within their practice. The eligibility criteria allowed active certified clinicians of any age, gender, and years of practice who provide direct wound care and evaluation to patients using Swift to complete the survey. Therefore, a screening question was added to the survey to allow only eligible participants who downloaded and used the application to provide a response. When potential participants answered no to using the solution, they were directed to the end of the survey.

Upon clicking on the survey link, an information note is displayed to participants outlining the reason for collecting the feedback. No identifiable information was collected, making the responses anonymous. The survey took about 10-15 minutes to complete. Participation was voluntary.

Survey Instrument

TAM and UTAUT were used as a theoretical lens to quantify users' perceived attitudes toward the digital technology, level of acceptance, and perceived efficiency to assess the likelihood of satisfaction and adoption of the new technology [17,22].

A systematic search of satisfaction surveys, digital technology, wound care, and digital wound assessment limited to English was conducted searching for surveys and instruments used by clinicians to assess satisfaction levels with adopting new technology in practice [26-30]. Relevant questions were used as a guide for the authors to develop this study questionnaire and develop a data-gathering tool. Survey questions were cognitively pilot tested for reliability by a diverse group of five community Registered Nurses (RNs) and wound-certified clinicians and two experienced researchers to assess the instrument wording, readability, and simplicity, applicability to participants' experience, length, and structure. Survey questions were consistently refined and adjusted based on the received feedback. The tool's face and content validity were determined through multiple discussions among the authors and iterative reviews.

The final simplified version of the survey consisted of 9 questions that included items designed to assess the convenience of the tool, performance expectancy, social influence, and perceived benefits. One question- with subcategories- addressed the perceived efficiency of using the application and the perceived performance expectancy. Of the remaining questions, four captured the practice pattern, including the role of the clinicians, the duration and frequency of use, and the number of wounds evaluated since the use of the application, while one question investigated the level of satisfaction with the wound application, and one assessed the likelihood to recommend it to other clinicians. Questions assessing practice patterns were in a multiple-choice format, while the others were categorical, with 5-point Likert scale response choices ranging from strongly agree/strongly satisfied to strongly disagree/strongly dissatisfied, or very likely to very unlikely.

Participants were provided with the option to provide further input in a comment box on the perceived benefits they experienced from adopting the solution.

Responses were anonymous, and participants had the choice to skip over questions should they prefer not to respond to them. This quality improvement study has been granted an exemption of ethics review from Pearl IRB.

Statistical Analysis

All data analyses were performed in the Statistical Package for Social Sciences (SPSS) (SPSS, IBM Corp, Armonk, NY. Version 28; 2022). A summary of descriptive statistics generated from numeric and categorical variables of survey responses and summary data was displayed as frequencies (%) or mean.

The Chi-square test was used to examine the association between categorical variables in relation to the length of use and number of assessed wounds. A binary variable was created for the length of use; clinicians who had used the solution for <9 months versus those that used the solution for ≥9 months of application.

A binomial logistic regression analysis was conducted to investigate the association of the predictor variables- attitude and perceived efficiency of the solutions' features and clinicians' practice patterns- on the likelihood of satisfaction with the solution. The model was statistically significant, $X^2(7) = 109.03$, $p < 0.001$. Hosmer and Lemeshow goodness of fit test = 0.721, indicating the model is a good fit. The model explained 36% (Cox & Snell R²)-58% (Nagelkerke R²) of the variance in satisfaction correctly classified 88% of the responses with a sensitivity of 92.8% and specificity of 68.2%.

Overall, a 2-sided P-value less than 0.05 was considered statistically significant.

Results

Clinicians' role and practice pattern

The survey link was sent to approximately 2,000 clinicians, of which 460 responses were received (approximately 23% response rate). A further 75 respondents indicated that they have not used the solution yet and were automatically excluded from the survey. 385 users started the survey (19%), of whom 342 completed the survey and were included in the analysis. Clinicians' roles and practice patterns are displayed in Table 1.

Table 1: Clinicians' practice pattern.

Clinician practice pattern	Participants N (%)
Nurses Role	
Registered nurse	145 (42.3%)
Licensed practical nurse.	120 (35.2%)
Nurse practitioner	77 (22.5%)
Length of use	
< 3 months	78 (22.8%)
3-< 6 months	69 (20.2%)
6--<9 months	36 (10.5%)
9-<12 months	43 (12.6%)
1-2 years	85 (24.9%)
>2 years	31 (9.1%)
Frequency of use	
Everyday	104 (30.4%)
Few times a week	138 (40.4%)
Once a week	35 (10.2%)
Few times a month	31 (9.1%)
Once a month	6 (1.8%)
Less than once a month	28 (8.2%)
Number of wounds cared for	
<100	170 (49.8%)
>100	172 (50.2%)

Clinicians' experience using the technology in relation to practice pattern

When clinicians were asked about their experience using the wound care technology, 81% stated they were satisfied with the solution and thought it captured accurate clinical information. The majority (86%) said they were able to successfully track wound progress with their patients. More than three-quarters (76%) agreed/strongly agreed that using the digital tool saved them time measuring wounds, and 77.5% felt it met their clinical needs and that they preferred the digital solution over the traditional, manual methods of wound measurement (Table 2).

Regarding the differences in responses based on the length of application use and the number of wounds assessed with the technology, we investigated the difference in responses for clinicians who had used the solution for <9 months versus those that used the solution for ≥9 months. Clinicians who used the solution for more than nine months were 9% more likely to be satisfied with the solution than those who used the solution for less than nine months (85.5% vs. 76.5%, $P=0.034$) (Table 2).

Also, clinicians who used the solution for more than nine months were 9.5% more likely to agree that the solution saves time in wound measurements (81.1% vs. 71.6%, $P=0.023$), 5.1% more likely to agree it tracks changes in clinical conditions (88.7% vs. 83.6%, $P=0.045$), 5.7% more likely to believe it supports effective collaboration (76.1% vs. 70.4%, $P=0.044$), and 5.6% more likely to think it meets clinical needs (80.5% vs. 74.9%, $P=0.043$) (Table 2).

Clinicians who assessed more than 100 wounds were significantly more likely to prefer the digital wound management technology over traditional methods of wound measurement than those who assessed less than 100 wounds (82.5% vs 72.3%, P=0.014). Moreover, they were more likely to believe that the solution saves time in wound measurements (81.3% vs 70.5%, P=0.012) (Table 2).

Table 2: Clinicians' experience using the solution by practice pattern.

	All Participants	Length of use <9 months	Length of use >9 months	P Value	Number of Wounds <100	Number of Wounds >100	P value
	N= 342 N (%)	N= 183 N (%)	N= 159 N (%)		N= 170 N (%)	N=172 N (%)	
Satisfaction Satisfied/Very satis	276 (80.7%)	140 (76.5%)	136 (85.5%)	0.034	131 (77.0%)	145 (84.3%)	0.365
Saves time in wound measurements Agree/Strongly agree	260 (76.0%)	131 (71.6%)	129 (81.1%)	0.023	120 (70.5%)	140 (81.3%)	0.012
Track changes in clinical condition Agree/Strongly agree	294(86.0%)	153(83.6%)	141(88.7%)	0.045	140(82.3%)	154(89.5%)	0.014
Support effective collaboration Agree/Strongly agree	249 (72.8%)	128(70.4%)	121(76.1%)	0.044	120(70.5%)	129(75.0%)	0.051
Meets clinical needs Agree/Strongly agree	265(77.5%)	137(74.9%)	128(80.5%)	0.053	125(73.5%)	140(81.3%)	0.013
Preferred over traditional methods Satisfied/Very satis	265 (77.5%)	138 (75.4%)	127 (79.9%)	0.043	123 (72.3%)	142 (82.5%)	0.014
Facilities capture accurate information Agree/Strongly agree	280 (81.9%)	148 (80.9%)	132(83.0%)	0.674	136 (80.0%)	144 (83.7%)	0.671

Likely recommend it to others Likely/highly likely	270 (78.9%)	139 (76.0%)	131 (82.4%)	0.041	130 (76.5%)	140 (81.3%)	0.505
Improves my productivity Agree/Strongly agree	220 (64.3%)	112 (61.2%)	108(67.9%)	0.039	102 (60.0%)	118 (68.6%)	0.035

Factors associated with clinicians' satisfaction -Logistic regression model

Of the eight predictors introduced to the model, only four were statistically significant: length of time the solution was used, efficient collaboration with another clinician, preferring the digital technology to traditional methods of wound assessment, and productivity at the workplace (Table 3). Odds Ratios using the “length of use” as the focus variable indicate that clinicians using the solution for more than nine months were 2.3 times more likely to be satisfied than those who used it for a shorter period. Clinicians who experienced efficient collaboration with other providers had 2.29 times higher odds of being satisfied with the solution. Clinicians preferring digital technology to traditional methods of wound assessment had 7.31 times higher odds of satisfaction. Finally, clinicians that perceived improved clinical productivity were 10 times more likely to be satisfied with the technology (Table 3).

Table 3: Factors associated with clinician’s satisfaction with Swift digital solution- Binomial Logistic Regression.

Effect	OR	95% CI of OR	P value
Saving time measuring wounds Agree (vs. do not agree)	1.341	1.025 - 3.574	0.558
Ease to track wound progress Agree (vs. do not agree)	1.115	1.370 -3.289	0.844
Efficient collaboration Agree (vs. do not agree)	2.291	2.928-5.656	0.047
Preference over traditional methods Agree (vs. do not agree)	7.318	2.746- 9.499	<0.001
Productivity in workplace Agree (vs. do not agree)	10.030	3.438- 10.259	<0.001
Ability to capture accurate info Agree (vs. do not agree)	1.802	0.285-2.257	0.677
Length of use More than 9 months (vs. less than 9 month)	2.334	1.940- 5.792	0.042
Number of cared for wounds >100 (vs<100)	1.913	0.531 -6.893	0.321

-2Logl = 180.985; Hosmer–Lemeshow $\chi^2(7) = 5.334, p= 0.721$; Nagelkerke R²=0.582. Overall percentage.88% Significant difference at P < 0.05, non-significance > 0.05

Open Ended Question

To understand any additional reflections on the solution's benefits, content analysis of the open-response question indicated a variety of benefits that clinicians have experienced with the digital tool post-implementation. Nine thematic characteristics were identified from the analysis as essential keys to the solution's success, of which 11 further sub-thematic categories emerged (Table 4).

The main themes that emerged from responses to the open-ended questions were a) participatory- patients clinician interaction, b) clinician empowerment, c) collaboration, d) standardized, consistent care, e) image quality, f) privacy, g) documentation comprehensiveness, h) accessibility,

Selected quotations related to each theme and subthemes were annotated under each theme and sub-theme and outlined in Table 4.

Table 4: Summary description of themes and related quotes.

Themes of Swift Medical Benefits	Sub-themes	Description	Sample Quotes
Participatory - Patients Clinician Interaction	Engagement	The collaborative tool facilitates patient engagement through the tracking feature that allows clinicians to show patients images of their wound and its healing progress over time.	<p>“Ability to show patients, who can’t see their wounds, to see the progress that has been made, in real time.”</p> <p>“The patients enjoy being able to see the progress of the wound photos especially if it is in a location, they are unable to visualize.”</p> <p>“Swift keeps patients involved in their own wound care.”</p> <p>“The ability to show patients where they started is extremely helpful.”</p>
	Compliance	The tool helps providers determine the best management plan with patients, which promotes better adherence to treatment and healing of wounds.	<p>“Increased patient compliance and therefore increased healing.”</p> <p>“Patients are able to see their progress which can be hard for them, and it is helpful in keeping their spirits up and positive.”</p>
	Improved Experience	Patients are able to understand their progress at each visit and view tangible changes by following the care plan.	<p>“Patient satisfaction in seeing progress from beginning to end with photos.”</p> <p>“Personal satisfaction of seeing wounds heal in record time.”</p>

<p>Clinicians Empowerment</p>	<p>Accessible, Quality Data</p>	<p>The tool helps clinicians readily access quality wound data.</p>	<p>“Great way to see wound progress through visual pictures and easy to measure more accurately.”</p> <p>“I really like the fact that I can track changes in the wounds.”</p> <p>“Able to see the change of wound status, from one picture to the next.”</p> <p>“Quick and easy searching for patients’ wounds.”</p>
<p>Collaboration</p>	<p>Comprehensive Provider Coordination</p>	<p>The tool enables the seamless communication of wound data and efficient collaboration between other members of the care team to support better wound management.</p>	<p>“Easier to consult with an Interprofessional team.”</p> <p>“Call the physician and Clinical Manager to discuss the progress of the patient with swift APP, wound care /photos, and documentation and we can recommend an appointment with a primary care doctor.”</p> <p>“Able to see previous wounds from the prior nurse.”</p> <p>“Swift makes it easier to collaborate with colleagues regarding complicated wound management.”</p> <p>“Effective collaboration with an extended health care team.”</p> <p>“Ease in communication of wound size and condition.”</p>

<p>Standardized, Consistent Care</p>	<p>Patient-centered Care</p>	<p>The tool supports standardized and consistent care through accurate and comprehensive documentation and easy access to patient information to support better wound monitoring and management.</p>	<p>“I love how we can see previous pictures of wounds. Even though patients have different nurses each time, patients can get consistent care because of this app.”</p> <p>“Consistency in overall wound care for each client and not having pictures saved onto personal phones.”</p> <p>“Has helped standardize wound orders and increased follow up.”</p> <p>“It makes documentation more consistent from clinician to clinician.”</p>
<p>Image Quality</p>	<p>Accurate and Consistent Quality Imaging</p>	<p>The tool is a reliable mechanism to capture accurate, clinically-calibrated wound images, regardless of who is taking the image.</p>	<p>“Pictures are so much clearer.”</p> <p>“Visualizing the skin injury and peri-injury tissue.”</p> <p>“Easy way to measure wounds more accurately.”</p>
<p>Privacy</p>	<p>Secure Access to Patient Data</p>	<p>The tool is a secure platform to easily capture, share and access patient data.</p>	<p>“Security of data. Instead of receiving photos by text message, we have a secured platform with a login.”</p>
<p>Documentation Comprehensiveness</p>	<p>Complete Documentation for Reimbursement</p>	<p>The tool captures all relevant aspects of clinical care with complete documentation, minimizing fewer claims and authorization denials.</p>	<p>“Really helps with re-authorization.”</p> <p>“Aides in getting insurance authorization.”</p>
<p>Accessibility</p>	<p>Remote Patient Monitoring</p>	<p>The tool supports virtual care models and remote patient monitoring, increasing patient access to care and reducing geographic barriers to care delivery.</p>	<p>“Moved from an in person wound consult to a virtual wound consult platform.”</p> <p>“Allows for wound recommendations without having to go to the patients’ home.”</p>

<p>Confidence</p>	<p>Clinician Confidence in Wound Care</p>	<p>The tool helps clinicians (and their staff) provide wound care with greater confidence and competence.</p>	<p>“I have witnessed a first-hand evolution in my clinicians as their confidence in wound care bloomed with the support of swift. They are better able to identify components of the wound based on the assessment tools.”</p> <p>“I think Swift is a great asset to anyone providing wound care!”</p>
--------------------------	---	---	--

Discussion

Our observational cross-sectional study aimed at assessing clinicians’ level of satisfaction with digital wound management technology and its perceived clinical benefits. The study also investigated the predictive factors associated with clinicians’ satisfaction with the technology. Overall, our study recorded high satisfaction (81%, N=247) among clinicians using the solution. Our findings noted significantly higher satisfaction and perception of clinical benefits –such as tracking clinical changes in wounds, saving time in assessing wounds, and effective collaboration –among those who used the digital solution for more than nine months and those who assessed more than 100 wounds. This study also identified predictive variables associated with clinicians’ satisfaction. Our empirical findings suggest that clinicians who believed that technology improved their productivity at work were ten times more likely to be satisfied with digital technology. Moreover, the likelihood of clinicians’ satisfaction with the technology increased two-fold for those who used the technology for more than nine months and for those who felt the technology enabled more efficient collaboration with other providers. Further, the odds of clinicians being satisfied with the technology increased by seven times if they preferred digitally enabled wound assessment over traditional manual methods of wound assessment.

Our observations suggest after adopting new digital technology, the clinician’s initial belief in the technology’s capabilities, value, and impact influences user satisfaction. This observation aligns with other studies that investigated the predictors of user satisfaction with new technology. For example, a longitudinal study explored the dynamic changes in the acceptance and use of a management solution in Hong Kong on satisfaction and continued use. Yuen and colleagues tested a growth model using a three-wave longitudinal survey. With the reported significant association between higher initial positive belief in technology, satisfaction and continued utilization, the authors considered the initial belief as an essential factor in predicting satisfaction and utilization of digital systems [31].

Relationship between initial Perception of technology and clinician satisfaction

Our study reported a strong link between users’ satisfaction with the wound care technology and their initial belief in its effectiveness over traditional, manual methods of wound assessment. This finding underscores the significance of allocating sufficient resources to change management and user training during the deployment and implementation of new digital healthcare solutions in order to increase positive perception of the technology, and ultimately greater user satisfaction and long-term utilization.

Accordingly, a proven change management approach is used to support the adoption of Swift Medical’s digital wound management solution. This includes engaging with clinical leaders to understand the workflows and current processes. Super-users are trained to lead the change within the organization and continue to conduct end-user training. Options are available for clinicians to receive education synchronously in in-person classrooms or remote settings or asynchronously with a learning management solution. Competency checklists are available for super-users to validate end users’ ability to use the wound management solution. Follow-up meetings are held with the adopting organization to provide feedback on the use of the wound management solution, optimize wound photography and enhance digital wound documentation practices by clinicians.

Relationship between length of use and clinician satisfaction

Further, Bhattacharjee and Premkumar (2004) study confirmed the strong link between initial positive perception and satisfaction with technology [32]. However, the study argued that this relationship could shift upward or downward as users continue using the technology and experience the solution [32]. In our study, a critical element associated with satisfaction with the technology was the length of use of the digital solution. Our finding showed a significant 9% increase in satisfaction with the prolonged use of the technology for more than nine months. The study’s findings are consistent with other studies that drew attention to the dynamic nature of beliefs and satisfaction throughout the different phases of

use [24,32-36]. In our study, the chances of increased satisfaction with the wound care technology are doubled with continued use. This finding highlights the importance of considering a holistic, long-term view when assessing user satisfaction, as the attitudes toward and acceptance of technology change over time [31]. Ongoing use of the technology would challenge the sustainability and adaptability of the technology in meeting users' needs, impacting acceptance and satisfaction with the experience. Simultaneously, perpetual satisfaction with the technology paves the way for continued use [37,38] and success with using the solution [39,40].

The value of prolonged use of technology is reinforced in our study by the reported significant increase in positive perception of many clinical practice benefits. Interestingly, in our analyses, not all perceived clinical benefits were directly associated with improved satisfaction. Some important clinical benefits -such as reducing time to measure wounds, ease at tracking wound healing, and the ability to capture accurate information-were not significant determinants of satisfaction. However, these factors could be indirectly associated with other significant determinants, such as the initial acceptance of the digital wound care tool and how it was significantly preferred over traditional, manual methods of wound assessment. Moreover, the value of these benefits became more evident over time. For example, clinicians who used the solution for more than nine months reported a significant 9.5% increase in their agreement that it saved them time in measuring wounds. The authors observed significant time savings with using the Swift Medical solution to complete wound assessments and documentation in another study at an outpatient clinic that adopted the system for two years. Clinicians who participated in this time-motion study were able to complete wound assessments 79% faster – at an average savings of 2.39 minutes – than manual assessment methods (0.54 vs. 2.53, $P < 0.001$) [19].

Positive experience with technology features supporting workflow with more extended solution use

The continuous use of the technology was also seen to increase positive attitudes toward valuable features that support clinical workflows. For example, with the prolonged use of the solution, clinicians reported a statistically significant 5.1% increase in their agreement that the solution made it easier to track changes in clinical conditions and a 5.7% increase in their agreement that the solution made collaboration with colleagues more efficient, supporting better patient management.

These findings could be attributed to the amount of clinical information available to clinicians through the digital solution, as data is captured in an objective manner to improve interprofessional

team collaboration and patient-provider communication. The evidence noted that an increased volume of information available to clinicians could improve collaboration-based activities among the care team and enhance patient-clinician interaction [41]. This increases satisfaction with the interaction process [41] and enhances patient compliance with their providers' management plans [42]. Hard-to-heal wounds often require an interdisciplinary approach, so the ability to share consistent and accurate clinical information may help with clinician communication and support improved satisfaction and patient outcomes.

Better tracking of wounds can be attributed to the solution's ability to capture accurate and consistent wound dimensions, tissue types, and risk data over successive wound evaluations and make this objective, longitudinal wound healing record available to the full care team - onsite or remotely - to enable more informed clinical decisions.

This is congruent with the clinicians' open-ended responses, in which they attributed their satisfaction with the solution to its ability to support the tracking of wound healing and facilitate better patient engagement by helping them feel more in control of their health. One clinician using the technology reported: "Patients can see their progress which can be hard for them, and it helps keep their spirits up and positive." This is also supported by the simplicity of sharing standardized and consistent patient data between clinicians, facilitating efficient, remote collaboration and follow-up.

Prior to the adoption of the solution, clinicians may track length and width, but the true surface area is not available due to the limitations of utilizing a paper ruler to record wound dimensions. It is hard to imagine a clinical program not having an objective measure of progress (e.g. A1C in diabetes or blood pressure in hypertension) [43], but this is too often the case in wound care. Access to objective measurements and a record of previous wound images- each calibrated for variable environmental factors, such as lighting, skin pigmentation, and distance - reduces potential bias. According to a clinician using the technology: "We can see previous pictures of wounds. Even though the patient has different nurses each time, a patient can get consistent care because of this app." Traditionally, documentation would document changes in tissue types in a narrative note, but it is difficult for any clinician to accurately reconstruct the changes in the wound with the limited manual information in patients' records alone [44]. Objective data in measurements and tissue types reduces the challenges of data variability [45] and compromised decision-making, and potentially increases the satisfaction of clinicians by reducing the cognitive burden.

Relationship between clinical Productivity and clinician satisfaction

Additionally, our findings showed that with clinicians feeling their productivity had increased using the solution, they would be ten times more likely to be satisfied with the technology. In our study, with prolonged use of the solution, clinicians reported a 6.7% increase in their belief that the solution increased their work productivity. Evidence shows that equipping frontline clinicians with technology that increases their efficiency [19], improves data accuracy and reduces errors [4,19], improves practice capacity, and elevates the quality of wound care [4, 46,47], which linearly progresses along with overall users' satisfaction with the adopted technology [31,47].

This salient finding emphasizes the necessity of considering work productivity when designing digital tools for better overall satisfaction. Given the current workforce shortages, burnout rates, and retention challenges in clinical settings across the country [48], it is especially critical to prioritize the adoption of technology that can help clinicians and support a seamless workflow - specifically in clinical areas such as wound care where there is such a shortage of specialist and formal training to support clinicians at the bedside.

Interestingly, results from our formative benefits evaluation studies conducted periodically to compare the performance of home health agencies after six months of adoption to the pre-adoption period (and to control groups) observed a favourable shift of up to 9% in the clinician roles used to staff home visits. Using Swift Medical's solution, many home health agencies made greater use of more cost-effective Licensed Practical Nurses (LPNs) and lowered the use of RNs to conduct in-home visits. RNs were still involved in the collaborative model and were available for quality assurance, education, and support as required. This shift allowed for better use of RNs' time and did not affect the quality of care as agencies experienced a decrease in the average days to heal a wound by 11.6-21.8% and a reduction in 60-day rehospitalization rates by up to 13.4% (unpublished benefits evaluation data).

Limitations

This study provides insight into clinician satisfaction levels with wound care technology. To build a theoretical logic that links clinicians' satisfaction with wound care technology to the uptake of the technology, it is essential to understand what factors influence this satisfaction and decipher the relationship between perceptions and beliefs about the technology and patterns of use. The study provides an overview of clinicians' perception and satisfaction with wound care digital technology from different types of clinical practice settings - home health care and hospital care across the US. This study obtained a fair response rate, and to our knowledge, this is the largest survey that collected responses about perception and satisfaction with digital wound care technology, providing

insight into the current state of practice among wound care nurses.

Despite the distinct information the current study provides, some limitations are important to note. This study is an observational study with a cross-sectional design that collected data at one point in time after the adoption of the digital solution and, by design, cannot detect causality; thus, detected relationships are presented as associations. In addition, there is the potential for self-selection bias among participants. It is possible that only clinicians who were motivated, willing, and able to respond were attracted to complete the survey, which might not represent all clinicians who adopted the system. Further, the study population was nurses- front-line wound care clinicians. Therefore, the results and conclusions may not apply to other healthcare providers.

It is also worth noting that the number of wound referrals differs by the size of the organizations. This has affected the number of cared-for wounds. Some establishments are large and admit many wound patients; some are small, with limited referrals. Therefore, although some clinicians might use the solution daily, they still evaluate a limited number of patients overall since adoption.

In addition, although our analysis controlled for available confounders, we acknowledge that not all possible characteristics that might have affected the results were collected in the survey questions and, consequently, were not adjusted for in the analysis. An example of this is the impact on satisfaction categorized by the clinicians' practice size and location. The number of wound referrals differs by the size of the organizations, and this is visible in the number of cared-for wounds in relation to the length of use.

Further, not adjusting for years of practice and overall comfort level with using technology, in general, is another limitation. The level of experience and knowledge of using digital tools might differ at each practice, impacting the reported outcomes. However, it is essential to note that all professionals using the digital tool have been provided with standardized training before adoption. Furthermore, follow-up meetings and sessions were held with users to provide feedback on using the wound management solution, optimize wound photography and enhance digital wound documentation practices by clinicians. All are crucial practices for methodological consistency and efficiency.

Conclusions

Our study reported several original determinants of satisfaction, such as the preference for digital wound assessment over manual methods of assessment, the belief that digital technology enabled more efficient clinical collaboration, and increased productivity in the workplace. Clinicians' satisfaction with technology increased over time. Some latent clinical benefits could be dormant at one phase of implementation, and then be a

considerable determinant in modelling the changes in satisfaction over time. For example, while the belief that the technology reduced the time to measure wounds, made it easier to track wounds, and enhanced the ability to capture accurate information were not significantly associated with satisfaction, these beliefs increased significantly with the prolonged use of the system. Users become more conscious of the solution's performance and qualities over time. Thus, it is essential when implementing a new technology to support the ongoing use to explore technology's compliance in meeting clinical needs and improving the experience.

Apprehension of technology could prevent clinicians from grasping benefits with the initial use. This study points to the length of use being an antecedent to and a significant drive of satisfaction and continuous utilization of wound care technology.

This paper demonstrates that a holistic understanding of what drives clinician satisfaction in practice is essential. The length of use complements beliefs and attitudes in evaluating end-users' satisfaction with the wound care technology and its benefits

References

1. Falcone M, Angelis B, Pea F, Scalise A, Stefani S, et al. (2021) Challenges in the management of chronic wound infections. *Journal of Global Antimicrobial Resistance*. 26: 140-147.
2. Tayyib N, Ramaiah P (2021) Nurses' Challenges in Wound Care Management- A Qualitative Study. *Journal of Clinical and Diagnostic Research*. 15.
3. Bills J, Berriman S, Noble D, Lavery LA, Davis KE, et al. (2016) Pilot study to evaluate the novel three-dimension wound measurement device. *Int Wound J* 13: 1372-1377.
4. Wang SC, Anderson JAE, Evans R, Woo K, Beland B, et al. (2017) Point-of-care wound visioning technology: Reproducibility and accuracy of a wound measurement app. *PLoS One*. 12: e0183139.
5. Foltynski P (2018) Ways to increase precision and accuracy of wound area measurement using smart devices: Advanced app Planimator. *PLoS One*. 13: e0192485.
6. Majeske C (1992) Reliability of wound surface area measurements. *Phys Ther* 72:138-141
7. Bowling FL, Paterson J, Ndiip A (2013) Applying 21st century imaging technology to wound healing: an Avant-Gardist approach. *J Diabetes Sci Technol* 7: 1190-1194.
8. Gray TA, Rhodes S, Atkinson RA, Rothwell K, Wilson P, et al. (2018) Opportunities for better value wound care: a multiservice, cross-sectional survey of complex wounds and their care in a UK community population. *BMJ Open*. 8: e019440.
9. Rodriguez-Calero MA, Fullana-Matas A, Miró-Bonet R (2021) Classification of Pressure Injury Stages and Skin Damage Photographs by RNs and Nursing Students in Spain: An Observational Comparison Study. *J Wound Ostomy Continence Nurs* 48: 403-409.
10. Squitieri L, Ganz DA, Mangione CM, Needleman J, Romano PS, et al. (2018) Consistency of pressure injury documentation across interfacility transfers. *BMJ Qual Saf* 27: 182-189.
11. Ousey K, Gilchrist B, Jaimes H (2018) Understanding clinical practice challenges: A survey performed with wound care clinicians to explore wound assessment frameworks. *Wounds International*. 9:10-15.
12. Gillespie BM, Chaboyer W, Allen P, Morely N, Nieuwenhoven P, et al. (2014) Wound care practices: a survey of acute care nurses. *J Clin Nurs* 23: 2618-2626.
13. Lloyd-Vossen J (2009) Implementing wound care guidelines: observations and recommendations from the bedside. *Ostomy Wound Manage*. 55: 50-55.
14. Buchan J, Aiken L (2008) Solving nursing shortages: a common priority. *J Clin Nurs*. 17: 3262-3268.
15. Chassin MR, Loeb JM (2011) The ongoing quality improvement journey: next stop, high reliability. *Health Aff (Millwood)*. 30: 559-568.
16. Sinsky CA, Biddison LD, Mallick A, et al. (2020) Organizational Evidence-Based and Promising Practices for Improving Clinician Well-Being. *NAM Perspect*. 2020:10.31478/202011a.
17. Marikyan D, Papagiannidis S (2023) Unified Theory of Acceptance and Use of Technology: A review. In S. Papagiannidis (Ed), *TheoryHub Book*. 2021.
18. Song EH, Milne C, Hamm T, Mize J, Harris K, et al. (2020) A Novel Point-of-Care Solution to Streamline Local Wound Formulary Development and Promote Cost-effective Wound Care. *Adv Skin Wound Care*. 2020 b; 33: 91-97.
19. Mohammed HT, Bartlett RL, Babb D, Fraser RDJ, Mannion D (2022) A time motion study of manual versus artificial intelligence methods for wound assessment. *PLoS ONE*. 17: e0271742.
20. Hu PJ, Chau PYK, Sheng ORL, Tam KY (1999) Examining the Technology Acceptance Model Using Physician Acceptance of Telemedicine Technology. *Journal of Management Information Systems*. 162: 91-112.
21. Yi M, Jackson J, Park JS, Probst JC (2006) Understanding information technology acceptance by individual professionals: Toward an integrative view. *Information & Management*. 433: 350-363.
22. Ajzen I (2011) The theory of planned behaviour: Reactions and reflections. *Psychology & Health*. 269: 1113-1127.
23. Schretzlmaier P, Hecker A, Ammenwerth E (2022) Suitability of the Unified Theory of Acceptance and Use of Technology 2 Model for Predicting mHealth Acceptance Using Diabetes as an Example: Qualitative Methods Triangulation Study. *JMIR Hum Factors*. 9: e34918.
24. Venkatesh V, Moris M, Davis GB, Davis FB (2003) User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly*. 273: 425.
25. Wixom BH, Todd PA (2005) A Theoretical Integration of User Satisfaction and Technology Acceptance. *Information Systems Research*. 16: 85-102.
26. Al-Gahtani SS, King M (1999) Attitudes, satisfaction and usage: Factors contributing to each in the acceptance of information technology. *Behaviour & Information Technology*. 18.
27. Kang YS, Lee H (2010) Understanding the role of an IT artifact in online service continuance: An extended perspective of user satisfaction. *Computers in Human Behavior* 26: 353-364.

28. Sockolow PS, Weiner JP, Bowles KH, Lehmann HP (2011) A New Instrument for Measuring Clinician Satisfaction With Electronic Health Records. *Comput Inform Nurs* 29: 574-585.
29. Palm JM, Colombet I, Sicotte C, Degoulet P (2006) Determinants of user satisfaction with a Clinical Information System. *AMIA Annu Symp Proc* 2006: 614-618.
30. Langbecker D, Caffery LJ, Gillespie N, Smith AC (2017) Using survey methods in telehealth research: A practical guide. *Journal of Telemedicine and Telecare*. 23: 770-779.
31. Yuen A, Miaoting C, Fred HFC (2019) Student satisfaction with learning management systems: A growth model of belief and use. *British Journal of Educational Technology*. 50: 2520-2535.
32. Bhattacharjee A, Premkumar G (2004) Understanding changes in belief and attitude toward information technology usage: A theoretical model and longitudinal test. *MIS Quarterly*. 28: 229-254.
33. Ma WWK, Yuen AHK (2011) E-learning System Acceptance and Usage Pattern. T. Teo (Ed.), *Technology acceptance in education: Research and issues* Rotterdam, The Netherlands: Sense Publishers. 201-216.
34. Mou J, Shin DH, Cohen J (2017) Understanding trust and perceived usefulness in the consumer acceptance of an e-service: A longitudinal investigation. *Behaviour & Information Technology*. 36: 125-139.
35. Venkatesh V, Davis F (2000) A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science*. 46: 186-204
36. Venkatesh V, Morris M (2000) Why don't men ever stop to ask for directions? Gender, social influence, and their role in technology acceptance and usage behavior. *MIS Quarterly*. 24: 115-139.
37. Horvat A, Dobrota M, Krsmanovic M, Cudanov M (2015) Student perception of Moodle learning management system: A satisfaction and significance analysis. *Interactive Learning Environments*. 23: 515-527.
38. Islam A, Azad N. (2015) Satisfaction and continuance with a learning management system: Comparing perceptions of educators and students. *The International Journal of Information and Learning Technology*. 32: 109-123.
39. Diep A, Zhu C, Struyven K, Blicck Y (2017) Who or what contributes to student satisfaction in different blended learning modalities? *British Journal of Educational Technology*. 48: 473-489.
40. Freeze RD, Alshare KA, Lane PL, Wen HJ (2010) Is success model in e-learning context based on students' perceptions. *Journal of Information Systems Education*. 21: 173.
41. Whitten P, Mylod D, Gavran G, Sypher H (2008) "Most wired hospitals" rate patient satisfaction: Considering the role of it as a variable in health care institution quality assessment. *Communications of the Association for Computing Machinery*. 51: 96-102.
42. Garman A, Garcia J, Hargreaves M (2004) Patient satisfaction as a predictor of return-to-provider behavior: Analysis and assessment of financial implications. *Quality Management in Health Care*. 13: 75.
43. Morrison F, Shubina M, Turchin A (2012) Lifestyle Counseling in Routine Care and Long-Term Glucose, Blood Pressure, and Cholesterol Control in Patients With Diabetes. *Diabetes Care*. 35: 334-341.
44. Hansen RL, Fossum M (2016) Nursing documentation of pressure ulcers in nursing homes: comparison of record content and patient examinations. *Nurs Open*. 3: 159-167.
45. Ramachandram D, Ramirez-GarciaLuna JL, Fraser RDJ, Martínez-Jiménez MA, Arriaga-Caballero JE, et al. (2022) Fully Automated Wound Tissue Segmentation Using Deep Learning on Mobile Devices: Cohort Study. *JMIR Mhealth Uhealth*. 10: e36977.
46. Hendrich A, Chow MP, Skierczynski BA, Lu Z (2008) A 36-hospital time and motion study: how do medical-surgical nurses spend their time? *Perm J* 12: 25-34.
47. Menachemi N, Powers TL, Brooks RG (2009) The role of information technology usage in physician practice satisfaction. *Health Care Management Review*. 34: 364-371.
48. Zhang X, Phillips Jr L, Bazemore A, Dadoo MS, Petterson SM, et al. (2008) Physician distribution and access: Workforce priorities. *American Family Physician*. 77: 1378.