Applying Visual Analytics to Develop a Web Application to Collect Real-time Clinician Well-being Levels in an Adult Academic Health System

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Introduction

Well-being is multi-dimensional and is influenced by physical, emotional, mental, social, and spiritual factors that interact together within one's environment and circumstances[1]. Many workplace factors that contribute to clinician well-being are also involved in influencing clinician burnout prevalence[2]. Improving clinician well-being and quality of life decreases the severity and prevalence of clinician burnout in addition to improving patient care[3]. Physician burnout has been defined as a "work-related syndrome" commonly characterized by high levels of emotional exhaustion, depersonalization, and dissatisfaction with one's career[4]. However, burnout is not limited to physicians. A 2020 survey of over 20,000 healthcare workers found that 49% of respondents experienced burnout[5]. From small to large scale consequences, clinician burnout affects medical errors and field attrition, which compromises the quality of patient care and increases costs related to medical errors, thus damaging the entire medical system[6]. Therefore, there is a pressing need to support clinicians in their workplace and develop interventions to reduce burnout and promote well-being. This system demonstration paper aimed to develop a web application to collect clinical well-being levels and provide real-time feedback through interactive visualizations to clinicians, team leaders, and hospital administrators.

Methods

A Well-being Check web application (app here after) was developed following the agile software application development and user-centered design principles. The app provides easy access to a survey with a summary visualization providing real-time well-being levels of the users in real time to each team member (Figure 1). The survey was designed with standardized and customizable questions to enable cross-team comparison while meeting individual team needs[7] (Table 1). A core team was formed including a physician champion, a medical informatician, and several hospital well-being experts. This team met weekly to discuss the strategic plan while reviewing the app and making recommendations. The visualization design followed Munzner's nested model.[8] Specifically, the problems and use cases of the visualization were discussed in the meeting. Then, the survey data were abstracted to generate summary statistics as well as word frequencies. Next, the survey summary statistics were displayed in an interactive visualization, as demonstrated in Figure 2. This visualization included user input data filters (Figure 2, A), charts (Figure 2, B-C-D) summarizing quantitative well-being trends over time, and word clouds (Figure 2, E) representing the word frequencies of qualitative well-being descriptors. Lastly, an algorithm was developed to convert the categorical well-being levels into a numerical well-being level (a composite score), which was then plotted above the stacked bars (Figure 2, D). Altogether, the app was developed and refined iteratively between September 2021 and February 2022 (6 months). Figure 1 shows the system flow of the app.

In terms of validation, the app was piloted with three units at our adult hospital, including an intensive care team (ICU), a nurse leadership team (LDR), and a rehabilitation team (REHAB). Separate meetings with each pilot team were held bi-weekly or monthly to test the app and collect feedback. This abstract reported three major validation tasks. First, legacy data of well-being levels collected from REHAB between August 2 and September 15, 2020 (31 days) were imported into the app to test the visualization capacity. Second, a statistical analysis was conducted to support one of the use cases identified in the meeting. Specifically, the discrepancy between the aggregated individual well-being level and the perceived team well-being level was quantified by calculating the Mean Absolute Error (MAE). Higher MAE represents an incongruence between team and individual well-being levels, which can cause discordant team dynamics and may require further exploration of root causes that include different priorities, situational factors, and systemic issues. Third, a survey was administered to collect user feedback from REHAB, with results quantified utilizing a system usability scale (SUS). The SUS scores were calculated based on the definition[9] and the scores of all participants were summarized statistically. A system with SUS score above 68 is deemed to have above average usability. The subscales of the SUS scores will be reported and expanded upon in the final manuscript.

Results

Figure 2 shows the mock-up of the visualization, which provides interactivity via filters and hover-over behaviors. A full version of the visualization with study data will be included in the finalized manuscript. The visualization of the legacy data from REHAB is shown in the video as supplemental material. Table 2 shows a summary of REHAB's individual and the perceived team stress. The MAE were 7.44, 6.68, and 10.89 for the physical therapists (PT), the occupation therapists (OT), and the speech therapists (ST), respectively. For PT and ST, the team's mean stress level was perceived to be higher than the aggregated individual stress level. Lastly, the SUS survey collected 23 responses from 8 physical therapists, 11 occupation therapists, and 4 speech therapists. The mean, median, standard deviation of the SUS scores were 80.22, 82.5, and 15.59, respectively. The SUS score distribution shows that the Well-being Check app had above average usability.

Discussion

Using user-centered design and agile software development as well as visual analytics design principles, this project developed a web application to elucidate clinician wellbeing levels. The app was validated by the legacy data, one of the use cases, and the SUS scores. Both the survey and visualization are highly adaptable to users' needs and provide insight into how clinicians are doing and can inform organizations to support their staff. Two major limitations of this study are that it only involves a single institution, and that the usability testing is preliminary. In the future, a more rigorous usability testing will be conducted using the think-aloud protocol and semi-structured interviews in addition to the SUS[9]. Qualitative interviews will also be conducted to assess the overall usefulness of this new tool. The app is being applied to other clinical teams, such as the neuromuscular and anesthesiology departments. The user feedback will be carefully addressed following the Institute for Healthcare Improvement framework as part of a quality improvement initiative[10]. Ultimately, the well-being data will be analyzed in conjunction with the electronic health records to examine the causes of well-being barriers.

Table 1. Survey question types and examples from the Well-being Check App

Type	# Questions	Team Using	Sample Question
Standard	4	All teams	What is your stress level today?
Optional	2	REHAB, ICU	What is your role on this team?
Additional	3	LDR	How often do you lose sleep over work-related issues?

Table 2. Statistical summary of REHAB well-being level

Role	MAE	Perceived team stress level > actual stress level (%)	Perceived team stress level < actual stress level (%)
PT	7.44	13	11
OT	6.68	7	13
ST	10.89	23	2

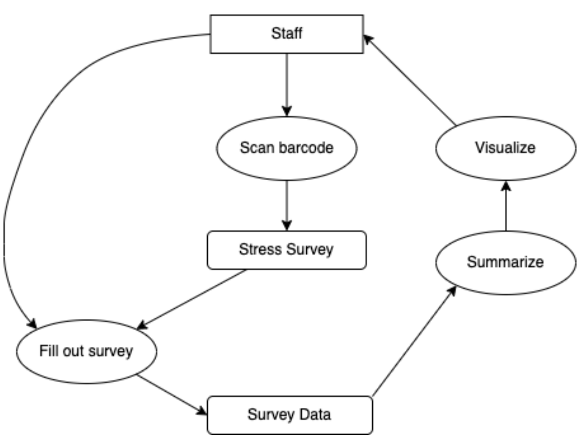

Figure 1. System flow diagram

Figure 2. Mockup of wellness check survey data visualization. A full visualization with color will be included in the finalized manuscript.

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