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Using mobile health technology to deliver decision support for self-monitoring after lung transplantation

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ABSTRACT

Background: Lung transplant recipients (LTR) experience problems recognizing and reporting critical condition changes during their daily health self-monitoring. Pocket PATH®, a mobile health application, was designed to provide automatic feedback messages to LTR to guide decisions for detecting and reporting critical values of health indicators.
Objectives: To examine the degree to which LTR followed decision support messages to report recorded critical values, and to explore predictors of appropriately following technology decision support by reporting critical values during the first year after transplantation.
Methods: A cross-sectional correlational study was conducted to analyze existing data from 96 LTR who used the Pocket PATH for daily health self-monitoring. When a critical value is entered, the device automatically generated a feedback message to guide LTR about when and what to report to their transplant coordinators. Their socio-demographics and clinical characteristics were obtained before discharge. Their use of Pocket PATH for health self-monitoring during 12 months was categorized as low (≤25% of days), moderate (>25% to ≤75% of days), and high (>75% of days) use. Following technology decision support was defined by the total number of critical feedback messages appropriately handled divided by the total number of critical feedback messages generated. This variable was dichotomized by whether or not all (100%) feedback messages were appropriately followed. Binary logistic regression was used to explore predictors of appropriately following decision support.
Results: Of the 96 participants, 53 had at least 1 critical feedback message generated during 12 months. Of these 53 participants, the average message response rate was 90% and 33 (62%) followed 100% decision support. LTR who moderately used Pocket PATH (n = 23) were less likely to follow technology decision support than the high (odds ratio [OR] = 0.11, $p = 0.02$) and low (OR = 0.04, $p = 0.02$) use groups. The odds of following decision support were reduced in LTR whose income met basic needs (OR = 0.01, $p = 0.01$) or who had longer hospital stays (OR = 0.94, $p = 0.004$). A significant interaction was found between gender and past technology experience (OR = 0.21, $p = 0.03$), suggesting that with increased past technology experience, the odds of following decision support to report all critical values decreased in men but increased in women.
Conclusions: The majority of LTR responded appropriately to mobile technology-based decision support for reporting recorded critical values. Appropriately following technology decision support was associated with gender, income, experience with technology, length of hospital stay, and frequency of use of technology for self-monitoring. Clinicians should monitor LTR, who are at risk for poor reporting of recorded critical values, more vigilantly even when LTR are provided with mobile technology decision support.

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1. Introduction

Lung transplantation has been increasingly performed in persons with end-stage lung diseases and has improved their quality of life and survival [1–3]. However, survival rates of lung transplant recipients (LTR) are still lower than those of other solid organ recipients [3]. Up to 75% of LTR are affected by infection and 55% by acute rejection in the first year [4,5], which are risk factors for chronic rejection, the primary cause of death beyond the first year [6,7]. Prompt recognition of condition changes that are associated with complications is crucial for improving recipients' survival. In addition to their regular follow-up visits to the transplant center, LTR are highly encouraged to perform daily health self-monitoring of spirometry, vital signs, weight, and symptoms at home, and to report any early signs of complications to clinicians [8].

However, LTR often have problems recognizing critical condition changes and making decisions about when to contact clinicians [9]. Although all LTR receive discharge instructions for detecting and reporting critical condition changes during home self-monitoring, LTR find it challenging to identify the thresholds of critical values for multiple health indicators, for example, the lower or upper limits of blood pressures, and to recognize critical changes from their own personal baselines [9]. Considering the amount of self-monitoring data generated by all LTR, it would be too time-consuming for clinicians to track and screen critical values for each LTR [10]. Patient engagement in self-management is important for the improvement of health outcomes [11,12]. Providing direct decision support for LTR to recognize critical values and report them to the transplant team may help the recipients engage in their own care and facilitate early interventions for the improvement of quality of life and survival.

Electronic spirometry systems have been reported to be reliable and valid for LTR health self-monitoring [10,13–15]. However, most electronic spirometry systems have been designed to send self-monitoring data to clinicians for interpretation, and do not provide decision support for LTR [15–19]. A few systems provide reminders or alerts for LTR to take action, such as reassessing their forced expiratory volume in the first second (FEV_1) when the values fall below a reference value [17], or contacting the transplant center when symptoms worsen [20]. Kugler et al. [21] described one electronic spirometry system that provided specific traffic light colors to warn patients on how to interpret and respond to lowering FEV_1 values.

Pocket Personal Assistant for Tracking Health (Pocket PATH®) is a smartphone application, developed by a multidisciplinary research team from the University of Pittsburgh and Carnegie Mellon University to assist LTR to monitor health indicators including spirometry, temperature, blood pressure, pulse, weight, and symptoms. Automatic thresholds for reporting critical values for each health indicator were determined by clinicians and programmed in the device. A full description of features of Pocket PATH was published elsewhere [22]. Main features of Pocket PATH include direct data entry of health indicators, both logged and graphical displays of data over time, and automatic decision support. When a critical value is entered into the device, the application automatically generates a feedback message, providing specific decision support for LTR about when and what to report to their transplant coordinators [22].

However, patients may not always adhere to self-monitoring recommendations. Non-adherence to the medical regimen in transplant recipients has been widely reported [23–27]. It is unknown whether transplant recipients would follow self-monitoring recommendations delivered by mobile technology, especially when reporting critical values is the concern. It is important to identify the factors that may affect the degree to which LTR follow technology-generated decision support recommendations for reporting critical values, which may help develop effective solutions to improve the self-monitoring and early identification of complications. Although a previous study of transplant recipients reported that demographics, social support, and perceived health were not associated with non-adherence to the medical regimen [28], no studies have explored whether such factors predict response by LTR to technology decision support for reporting critical values.

No previous conceptual framework has been specifically utilized to identify factors associated with appropriate response to technology decision support for reporting critical condition changes during patient health self-monitoring. Based on a widely used technology acceptance model, the Unified Theory of Acceptance and Use of Technology (UTAUT) [29], and the literature [30,31], two exploratory models (Figs. 1 and 2) were proposed to guide this study. The models posit that socio-demographic factors and context-related facilitating conditions, such as clinical characteristics and health status, health control beliefs, self-care agency, and environmental factors, may affect responses by LTR to technology decision support for reporting critical values. In addition, the frequency of use of mobile technology for health self-monitoring may be associated with following technology decision support for reporting critical values. The models propose that use of mobile technology may be a potential moderator or a mediator of the relationships between predictors (socio-demographics and facilitating conditions) and appropriately following technology decision support, respectively.

Using the Pocket PATH intervention as an exemplar of a mobile health (mHealth) technology with decision-support features, the purposes of this study were to: (1) determine the degree to which LTR responded appropriately to mHealth technology-generated decision support feedback messages by reporting critical values, (2) explore predictors of appropriately following technology decision support during the first 12 months post-transplantation; and (3) assess whether the frequency of using the Pocket PATH intervention influenced the relationships between predictors and appropriately following technology decision support for reporting critical values.

2. Materials and methods

2.1. Study design and sample

A cross-sectional correlational design was utilized to analyze existing data from a randomized controlled trial evaluating the efficacy of Pocket PATH intervention compared to usual care for promoting self-monitoring during 12 months post-lung transplantation. The sample was comprised of 96 LTR who were from the Pocket PATH intervention group. All participants were recruited from December 2008 to December 2012 at the acute cardiothoracic unit of the University of Pittsburgh Medical Center. They were at least 18 years old, with no prior organ transplant, stable enough to be discharged from the hospital, likely to be involved in their own post-transplant care, and able to read and speak English. Details of the protocol have been published elsewhere [22,32]. The mean age of the sample was 57 years ($SD = 14$). Most were male (51%), white (93%), currently married (74%), unemployed (84%), with more than high-school education (56%), with their basic needs met by current household income (89%). More than half (54%) were re-hospitalized at some point during the first year post-discharge.

2.2. Procedure

LTR received a 30–60 min technology training session before discharge from the hospital. They were instructed to enter their spirometry data, vital signs, and symptoms into the daily checklist of Pocket PATH. The application was programmed to generate auto-