Effective Remote Patient Monitoring (RPM) System in Managing Population Health for Patients with Hypertension

Suilk Park, MS1, 2, Mark A. Lawley, PhD2, Hye-Chung Kum, PhD1, 2, 3
1Population Informatics Lab, Texas A&M School of Public Health, College Station, TX; 2Industrial & Systems Engineering, Texas A&M University, College Station, TX; 3Health Policy & Management, Texas A&M School of Public Health, College Station, TX

Introduction
Remote patient monitoring (RPM) is an automated technology for the transmission of data on a patient’s health status from home to the respective healthcare setting. RPM is a promising strategy for improving chronic disease management by facilitating early clinical intervention and providing cost-effective care. Many studies have suggested improvements in patient health by using an RPM system while some studies did not show significant benefits, perhaps because of low adherence rates, or poor handling of situations when patient’s vital signs are outside of normal ranges. To date, most studies focus on developing and implementing RPM systems that enable the continuous data flow. There has been little effort to study what makes an RPM system effective in managing population health.

Objective
The purpose of this research is to evaluate design features of the RPM system by conducting a case study of data from a RPM company in Texas to identify key elements of the system that improve population health.

Methods
There was a total of 823 patients, with hypertension, enrolled in Medicaid, and who initiated RPM for blood pressure and pulse from January 2016 to June 2018. Our main analysis covered the population of patients that were monitored for at least six months. We also analyzed the clinical effectiveness in the sub-population of 202 patients who had a greater need for RPM indicated by red or yellow alerts within 30 days after enrollment and with higher adherence (=transmission) rate (> 0.8). There are two key processes in using the RPM system effectively: two automated alerts (the computer process) and corresponding two follow-up phone calls (the human process). Automated alerts were generated when vital signs were not transmitted on time (adherence alerts), or the values exceeded preset thresholds (clinical alerts). Daily transmission times were set by patients and the vital sign thresholds were set by the primary physician. Both alerts were followed up with a phone call to the patient or caregiver. Non-clinical staff followed up on adherence alerts with reminder calls to troubleshoot in order to receive the daily reading and improve the transmission rate. Clinical staff followed up on clinical alerts and classified the situation as red, yellow, or green, depending on the real clinical severity and followed set protocols. Green means no clinical intervention is required, and email is sent to designated people. Red or yellow each mean clinical intervention is required, and email is sent with the phone call to the clinical contact. In rare cases for red alerts, the clinical staff may contact 911. Weekly reports were transmitted to primary care physicians with the vital signs and alert classification so physicians could efficiently monitor their patient panel. We conducted a trend analysis on the population to examine daily trends during the six-month study period. We modeled the (1) daily transmission rate (% of patients in the program who transmitted their vital sign on any given day), the (2) daily supported transmission rate (% of patients who required a reminder call to transmit their vital sign of those that transmitted their vital sign on a given day), and the (3) daily clinical alert rate (% of patients whose blood pressure or pulse was out of a defined range of those that transmitted their vital sign on a given day). The supported transmissions are patients who only responded after a reminder call. Linear models were used to estimate changes over time from the second to sixth month after enrollment in RPM. The first month was excluded from the trend analysis because most patients seem to take one month to get on the RPM system.

Results
The average age of the patients was 73 (SD=12), with 65% female, and thus almost all being dual eligible for Medicaid and Medicare. Patients lived in a zip code close to the primary physician and typically worked with one physician during the study period. However, 3% of patients had switched doctors during the study period. Within six months of enrollment, on average, patients transmitted their vital signs for 75% of the days, but 17% of these days required a reminder call. 93% of patients had thresholds for diastolic/systolic blood pressure set as 60/90-90/160 mmHg and pulse set to 60-120 beats. On average, a patient had 42% of their monitored days exceed at least one threshold. On average, non-clinical and clinical staff called 10 and 7 patients in an hour (SD= 4.8 and 4.1), respectively.
As a population, the percent of patients with vital signs out of a defined range on any given day declined from 44% in the second month to 39% in the sixth month of the study providing evidence that the RPM system was effective in managing population health. More specifically, among 823 patients in our population, from the second to sixth month, on average daily transmission rate was 77%=636 patients (SD=2.6%), supported transmission rate was 23% (SD=1.8%), and clinical alert rate was 41% (SD=2.4%). In our linear spline model, as expected there was a slight decline in the transmission rate over time, at a rate of 9.4 patients less a month (p<0.001). This amounts to a total of 47 patients no longer transmitting their vital signs in the last month compared to the second month (Figure 1 (a) blue dots). There was no statistically significant change in the supported transmission rate over time (p=0.44; Figure 1(a) pink squares), which accounted for almost a quarter of the daily transmissions. This indicates the importance of these reminder calls in continuing to monitor the patients over time. Most importantly, from those monitored patients, the linear spline model indicated that on average, 9.6 more patients a month were able to bring their vital signs under control (1.2% decrease a month; p<0.001; Figure 1 (a) green triangles). That means, an increase of 48 patients who had their vital signs under control by the last month.

The effectiveness of the RPM program in increasing the number of patients with their vital signs under control for the subpopulation of 202 patients, who both needed the RPM program the most and were adherent, were even better. From the second to sixth month, on average daily transmission rate was 92%=185 patients (SD=2.1%). The transmission rate declined by only 0.5 patients a month (p=0.02), resulting in only 2.7 less patients in five months (Figure 1 (b) blue dots). Of the monitored patients, the supported transmission rate was 19% with no statistically significant change over time (p=0.44; Figure 1(b) pink squares). The clinical alert rate declined from 51% to 45% within five months, at a rate of 2.8 patients a month (1.4% decrease a month; p<0.001; Figure 1(b) green triangles). That means 14.2 patients got their vital signs under control during the five-month period.

**Conclusion**

On any given day, a little less than 8 in 10 patients registered for the RPM program transmitted their vital signs, with a quarter of them needing a reminder call for the transmission. 7.5% of these monitored patients kept their vital signs under control in five months using the RPM program consisting of quick follow up calls from clinical staff when vital signs were out of a defined range and weekly review of vital signs by physicians to support timely clinical intervention. The impact is even greater for patients who had a greater need and were regularly transmitting their vital signs with 7.7% of monitored patients getting their vital signs under control.

RPM is an innovated technology that allows patients to be monitored in near real-time so that physicians can intervene early if there is evidence of clinical deterioration. However, transmitting vital signs daily requires patients to be diligent and quick actions are needed when vital signs are out of range in order for the RPM system to be effective. We found that both non-clinical and clinical follow-up phone call processes at appropriate times could help to have higher transmission rate and to control the vital signs. Further analysis is needed on the impact of RPM on mortality and rehospitalization rates.

**References**