Redesigning Chronic Care delivery using Mobile Health Technology

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Abstract

Typical management of chronic conditions is through sporadic office visits. But health indicators (such as blood pressure) can fluctuate significantly within a day. The infrequent office visits, however, offer the provider little information about the medical history of the patient between office visits resulting in delayed and sometimes inappropriate interventions. Use of mobile health (mHealth) technology in clinical care can help make appropriate interventions at the patient's location before the worsening condition leads to costlier consequences. mHealth enables patients to remotely upload measurements and providers to continuously monitor these measurements and intervene if necessary. mHealth, therefore, results in bidirectional information flow between providers and patients, thereby reducing information asymmetry. Our study examines redesigning of chronic care delivery using mHealth. It is important to make sure the redesigned delivery process is both efficient (reduces cost) and effective (improves patient health). In this paper, we first present a big picture of the redesigned care delivery process. We then show how this delivery process can improve patient health by analyzing a panel dataset of 1627 patients. We examine the relationship between use of mobile health applications and quality of care delivery for hypertensive patients. We observe the blood pressure readings to decrease with frequency of app usage and time since adoption. With the use of mHealth apps increasing in the post COVID-19 era, our analysis indicates an efficient use of physician's time and an increased role for support-staff under the supervision of the physician. The chronic care delivery process can therefore be redesigned with the help of mHealth, improving patient health and reducing cost for both patients and providers.

1. Introduction

In the United States today, about half of all adults have one or more chronic health conditions. Seven of the top ten causes of death in 2014 were chronic diseases (CDC, 2017). Patients with chronic conditions are also more susceptible to contagious diseases like COVID-19 (Richardson, et al., 2020).

Chronic disease and the delivery of care to manage and treat these conditions may be one of the most important issues facing our society today, particularly as evidenced by the high number of diagnosed cases as well as the high proportion of healthcare costs that are attributable to chronic diseases (Milani and Lavie, 2015; Baker, 2001; Wagner, et al., 2001). For example, the estimated cost of diagnosed diabetes for the U.S. population was $245 billion in 2012, including $69 billion in lost productivity (American Diabetes Association, 2013). Hypertension and diabetes are two of the most prevalent chronic conditions on a global level. It is important to prevent or manage these conditions as quickly as possible to limit the long-term damage to the body and reduce cost to the healthcare system, and it is imperative that preventive interventions are put in place to mitigate this growing problem (Smith and Topol, 2013).

Current chronic healthcare delivery typically relies on the primary care physician as the first point of contact. Given that the median length of these interactions are less than 15 minutes and cover 6 topics, little time is available to assess and address patient behavior (Milani and Lavie, 2015). While national guidelines and standard processes for treatment exist, chronic disease patients typically receive only half the recommended process of care, making additional interventions necessary and increasing the total cost of health care (Milani and Lavie, 2015; Wagner, et al., 2001; Wagner, et al., 2005). Thus, the quality of chronic health care that patients receive is deficient. Deficient care is a result of four factors: physician time demands, rapidly expanding medical database, therapeutic inertia (the failure of a provider to increase or modify therapy when treatment goals are not met), and lack of supporting infrastructure (Milani and Lavie, 2015; Wagner, et al., 2001). For a detailed discussion, one can refer to Agnihothri & Agnihothri (2018).

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2. Chronic care supply chain

The current healthcare delivery system is designed to deliver optimum acute care. However, there is significant difference between acute and chronic care. Acute care is episodic, and all the care is delivered within a short period. There is no long-term follow-up required in the case of acute care. Unlike an acute illness that typically lasts only for a short time, a chronic illness develops slowly and may worsen over an extended period. Chronic illness requires a long-term medical plan to keep it under control as much as possible. While the focus in acute care is swift recovery of the patient, the focus in chronic care is to manage the condition to minimize patient discomfort, slow disease progression, and improve quality of life as much as possible in the long run. Thus, chronic care happens throughout the patient's life, as the underlying patient condition needs to be both treated and managed. This requires continuous information sharing between patients and providers.

If the goal is improving patient health outcomes, one must understand the complexity of care delivery supply chain (SC). This is analogous to the physical product SC where information sharing to resolve coordination issues has been well established. The primary objective of supply chain operations is to have the right product (high quality, patient-specific timely interventions) at the right place (patient's location) at the right time (before expensive interventions are necessitated by the worsening condition). However, healthcare has lagged other sectors in adopting best supply chain practices (Lee, et al. 2006). From the supply chain perspective, three major stakeholders (players) within chronic care SC are the patient, physician, and healthcare organization. Of course, there are also many other stakeholders within the healthcare organization, but they are arguably secondary, and we therefore ignore them here. SC coordination requires each stakeholder to share information and consider the impact its actions have on other stakeholders. A lack of coordination occurs if information moving between players are delayed and distorted, e.g., if BP readings are unavailable in a timely manner or, are inaccurate. There are behavioral obstacles that contribute to information distortion. If all stakeholders in the chain, especially patients and physicians, take coordinated actions, then the total supply chain surplus increases (health outcomes improve and cost reduces).

Patient-provider coordination and better information sharing can be enabled through informatics, information and communication technologies, particularly mobile health (mHealth) applications (apps). These apps show how integrating the fields of information system and operations can increase patient value (see Figure 1 and Agnihothri & Agnihothri, 2018). A detailed discussion of pros and cons of using mHealth is provided by Agnihothri et al. (2020). In what follows, we focus on mHealth apps designed to manage one of the chronic diseases, hypertension.

mHealth apps for hypertension can be helpful in the following ways. First, instead of an infrequent, office-based treatment approach, mHealth apps can be

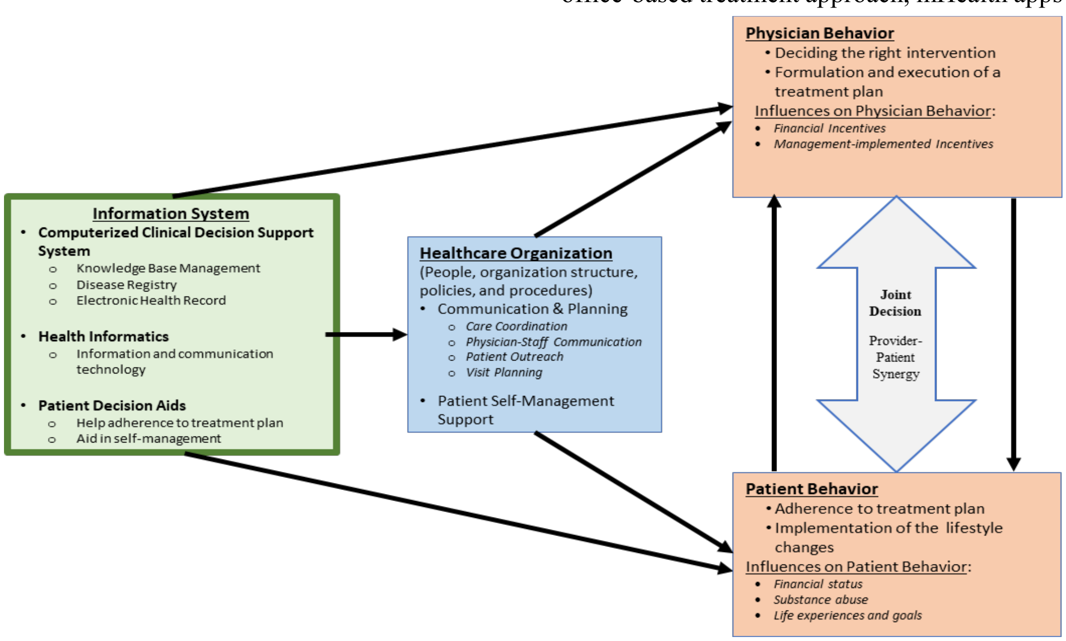

Figure 1: OM-IS interface in chronic care delivery

used to collect and communicate data on patient vitals to the provider. Second, they enable continuous monitoring of patient condition by the provider, enable interventions in the form of timely communication, and therefore reduce the likelihood of therapeutic inertia. Third, patient vitals data collected by the patient can increase self-awareness and improve patient self-management of their disease. Fourth, they are aligned with Patient Centered Care (PCC) as the care originates from patients who provide important information through mobile apps.

It is important to make sure the redesigned chronic care delivery method using mHealth technology satisfies the operational objectives of improving patient health and improving efficiency of the delivery process (example, reducing cost). In this paper, we discuss the former. We evaluated improvement in patient health (indicated by blood pressure readings) at a hypertension clinic that uses an mHealth app for some of its patients. The clinic has been using a proprietary mHealth app for over eight years to treat patients with diabetes and hypertension. Patients opt in to use the app but whether the patient chooses to do so, and how often the patient uploads a reading, are solely decided by the patient. Thus, we did an observational study of patients using an mHealth app in addition to regular office visits.

3. Literature Review

The literature on mHealth spans multiple disciplines. We provide a review of two main, but separate, streams of literature that are related to our study: information sharing and coordination in supply chain (SC) and effectiveness of mHealth apps. We first discuss the former and show how very little research has been conducted by putting the patient at the center of the service SC and focusing on patient information.

Importance of coordination in managing supply chains for physical products has been studied extensively in the SC literature and we refer the readers to Kanda et al. (2008) for a review. For product SC it is well established that information asymmetry creates inefficiency and information exchange has been touted as instrumental for coordinating actions in a SC (Lee, Padmanabhan, and Whang, 1997; Fiala, 2005; Ha, Tian, and Tong, 2017).

In service-dominant healthcare SC, clinical care is the dominant function, and the patient often fulfills the role of the manufacturer (provider) and the customer (patient) simultaneously. Hence, service SC needs a different framework to include bidirectional information flow and consider different roles of the customer (see for example, Sampson and Spring, 2012; Maull, Geraldi, and Johnston, 2012; York, Wainright, and Chen, 2018). Information asymmetry is therefore much more difficult to deal within service firms. Wang et al. (2015) provide a comprehensive overview of research in service SC. The literature on information sharing in the healthcare context often explores providers, which though significant, has only an indirect impact on patients. For example, coordination between physicians and hospital staff (Dobrzykowski and Tarafdar, 2015), hospital-supplier collaboration (Hu, Schwarz, and Uhan, 2012), hospital-physician integration (Zepeda, Nyaga, and Young, 2020), funder-provider coordination (Guo, et al., 2019) all influence the SC but does not address the critical issue of coordination between the provider and the patient. The use of technology to achieve coordination in healthcare SC has focused mostly on the provider side (e.g., Agarwal, et al., 2010; Queenan, Angst, and Devaraj, 2011; Devaraj, Ow, and Kohli, 2013; Bavafa, Hitt, and Terwiesch, 2018).

York et al. (2018) propose a redesign of the healthcare SC to align with the Triple Aim mission which is to improve patient experience, improve population health, and reduce cost (IHI, 2010). Especially for lifelong chronic care (in contrast to one-time episodic or acute care), regular updates on patient-specific information become crucial to manage patient health condition and treatment. Patient-provider integration in a chronic healthcare setting is discussed in conceptual detail by Agnihothri & Agnihothri (2018). While these researchers have observed the asymmetry in the healthcare setting, to implement such designs widely there is a need to quantify the impact and measure their effectiveness. mHealth could play a pivotal role in the SC redesign, reduce delays in bidirectional information flow, improve accuracy and timeliness of decision making, and help in managing chronic conditions. However, evaluation of app-effectiveness is one of the major challenges (Varshney, 2014).

In summary, chronic healthcare should be driven by patient and such patients can be managed effectively and efficiently using regular (continuous) updates on patient information rather than sporadic updates through office visits. While researchers have acknowledged the presence of information asymmetry and looked at the provider side to improve SC coordination, to the best of our knowledge, OM researchers have not studied the effectiveness or quantified the impact of technology in resolving patient-provider asymmetry or attaining coordination, and we attempt to address this gap. Our attempt is also an answer to the call by Kumar et al. (2018) to explore the interface between operations and information systems. They mention three areas where information systems can be used to solve operations management problems and our study is related to all these three areas: Information sharing across supply chain (using mHealth to improve patient-provider coordination), improving quality of healthcare delivery (using mHealth to reduce hypertension), and omni-channel systems (provider using both in-person and mHealth to provide patient care).

We next provide a detailed review of the medical literature on one such technology: mHealth apps. A comprehensive review of the medical literature on mHealth apps is beyond our scope but we summarize a subset here that is most relevant to our study. We focus on studies that are specific to hypertension or regulating blood pressure, and we also narrow down to effectiveness studies with physician supervision and not just feasibility pilots, or self-management apps (of which there are several).

Researchers have established the benefit of regular and prolonged use of blood pressure telemonitoring compared with usual care. The benefit is based on tele-counseling and case management under the supervision of a team of healthcare professionals. We mention below two recent systematic reviews. Alessa et al. (2018) conducts a systematic review of 21 studies with a total of 3112 participants (range of 19 to 1012 participants). Parati et al. (2018) summarize the findings of recent meta-analyses. Included in the review are two large meta-analyses studies that included 69 randomized controlled trials (RCT) with 20,912 cases in total. The RCT studies in the literature measure outcomes in a tightly controlled environment. Thus, in these studies, the estimated treatment effect of mHealth app usage on health outcomes is only for the prescribed course of mHealth use within the experiment setting and may not be generalized for mHealth use in general. For instance, in Logan et al. (2012), to measure the effect of telemonitoring on blood pressure, "all of the eligible subjects were asked to monitor their BP at home daily for 7 days, taking 2 readings in the morning and 2 readings in the evening using a validated Bluetooth-enabled home BP device." It is unclear whether the treatment effect described here applies to mHealth use in general, because if patients are not part of the experiment, they may go weeks, or even months, between readings. In contrast, the physician in our study simply gives patients the option of using mHealth, and it is up to the patient how often and when they use the app. To illustrate this point, in the dataset we consider, 95% of the patients who used the mHealth app uploaded at least one measurement every month on average. The maximum time between uploads for a patient in our dataset was 9.84 months. Thus, our dataset reflects what one might observe in a non-controlled setting, allowing for individual variations in actual usage.

4. Estimating the impact of mHealth app on patient health

4.1 mHealth app - Description and Capabilities

The clinic physician worked closely with a software developer and developed a robust, flexible, user-friendly, web-based, proprietary mHealth app, hereafter referred to as "the app". In its current form, the app is being used in his clinical practice for over eight years. As far as we know, this is the only fully integrated app that is in regular use in a clinical practice that enables patients to continuously communicate data on their vitals while the provider monitors, intervenes, and gives timely feedback. The app allows patients and doctors to monitor patients' blood pressure, blood sugar, pulse, height, weight, smoking status, and other vital signs. All patients own a physician-recommended, cuff-based, BP measurement device. Patients are instructed on recommended guidelines and are specifically trained in using the device. The device is calibrated by the support staff in the beginning and every six months. Patients are encouraged to take several readings in a row to get a better estimate. Abnormal readings are checked by a validation coordinator to ensure accuracy, i.e., she asks the patients to take multiple readings.

The app has a built-in decision support system enabling providers to make timely and informed patient interventions. The app (i) communicates instantly with the provider to make immediate treatment modifications, if needed, (ii) allows broadcasting of chats and connects providers in real time with patients to intervene, (iii) sends alerts to patients reminding them to enter vitals on time, (iv) sends a summary document automatically to the patient's Electronic Medical Record so that patients can have a macro view of their readings.

The app was released at the end of 2014. Patients can install the app on their phone or computer, enabling them to upload readings. Whether or not the patient chooses to opt into the app, and how often the patient uploads a reading, is solely decided by the patient.

4.2 Data description and prior work

Our dataset had two cohorts: adopters who adopted the app and non-adopter who did not adopt the app. We classify patients into three categories: healthy, stage 1 hypertension, and stage 2 hypertension, using the value of their initial systolic reading, to give some idea of their health state. Based on 2017 American Heart Association guidelines (see Whelton, et al., 2018), "healthy" patients have systolic readings under

130 mmHg, “stage 1” patients have systolic readings between 130 mmHg and 140 mmHg, and “stage 2” patients have systolic readings above 140 mmHg.

The dataset included 1633 patients whose readings were observed between 2014 and 2016. It also included patient age, gender, race, BMI, smoking status, alcohol consumption status, and systolic and diastolic BP readings measured at the office.

Using a difference-in-difference analysis, we first analyzed the change in office-based blood pressure reading at least 12 months apart. We found the difference-in-difference estimates to be 4.01 mmHg systolic for stage 2 patients and 1.89 mmHg systolic for an average patient. Details can be found in our published work (Agnihothri, et al., 2021).

In this paper, we focus on the readings uploaded through the app, in contrast to office-based readings which were analyzed in our prior work (Agnihothri, et al., 2021). Our app dataset also consists of 242,437 blood pressure readings uploaded by 960 different patients between 2014 and 2016. For each reading, we record the patient ID, date and time of the upload, and the systolic and diastolic blood pressure of that upload.

4.3 HBPM Data Analysis

In this section, we will analyze HBPM (Home Blood Pressure Measurements) data uploaded through the app. A detailed picture of how patient blood pressure evolves over time using the app is needed to understand the benefits of the app. In this section we establish that both a longer time of app adoption and a higher rate of app uploads are associated with lower blood pressure as well. We emphasize that these results only show that heavier app use is associated with lower blood pressure, but do not give any insights about which feature of the app is causing this health change. However, we conclude this section by making some observations on patient's behavior that may explain the drop in blood pressure.

We proceed to investigate the benefit of the app by checking if patients that are more engaged with the technology exhibit a larger improvement in their blood pressure. To do so, we calculate an additional measure, called *nReading*, that is associated with each reading. It is the number of times a reading has been uploaded into the app before this reading. We wish to check whether this measure has any significant impact on the systolic blood pressure reading, that is, whether using the app more often will cause blood pressure to drop. We regress blood pressure on *nReading,* that is, we use HBPM as the dependent variable and nReading as the independent variable. We include patient fixed effects to control for individual time-invariant characteristics but omit time fixed effects because it is unlikely that there are any events over the course of such a short period that would systematically affect patient health.

After performing this regression, we repeat it twice: once using the subset of patients who are not healthy (above 130 mmHg initial systolic blood pressure), and once using the subset of patients who suffer from stage 2 hypertension (above 140 mmHg initial systolic blood pressure). These regressions identify whether the effect of the app is higher for patients with more serious health conditions. We find that in general, every additional reading uploaded is associated with a 0.0004 mmHg systolic blood pressure drop, but this effect increases to a 0.002 mmHg systolic blood pressure drop for patients who suffer from either stage 1 or stage 2 hypertension and increases to a 0.003 mmHg systolic blood pressure drop for patients who suffer from stage 2 hypertension. See Table 1 for these regression results.

Although we have established that more app use is associated with a drop in blood pressure, one issue that is worth investigating is whether this effectiveness is always present, or if it suffers from a “fade-out” effect where the beneficial effect of blood pressure is strong immediately after adoption and weaker later. This is quite common for other uses of technology. For instance, Brynjolfsson & Yang (1996) documents a “productivity paradox” for computers: despite an explosion in both the availability and power of computers from 1970 to 1990, the production rate in the US over the same period decreased.

	Dependent variable: Systolic BP (mmHg)		
	All	BP<130	BP≥140
nthReading	-0.0004*** (0.0001)	-0.002*** (0.0001)	-0.003*** (0.0001)
Observations	242,437	108,985	63,894
R-sq.	0.0002	0.002	0.005
Adj. R-sq	-0.004	-0.002	0.002
F-stat.	52.5***	211.6***	343.6***

*p<0.1, **p<0.05, ***p<0.01

Table 1: The effect of increased app use on blood pressure.

We can see this effect visually in Figure 2. Using HBPM data, we first find the date of the first app upload for each patient. Then for each reading within our HBPM dataset, we calculate the length of time (in months) between that reading and the time of the first app upload for that patient. This is the cumulative length of time, or *timeOnApp* that the app has been used for each reading upload. Then, for each possible value of *timeOnApp*, we report the average app reading for all uploads meeting this criterion and plot this information. Finally, we make three plots based on whether the patient's initial reading is under 130 mmHg (healthy), between 130 mmHg and 140 mmHg (stage 1 hypertension), or over 140 mmHg (stage 2 hypertension). This plot can be found in Figure 2 and shows how blood pressure changes over time with the use of the app, depending on the patient's initial health status.

It does not appear that there is a fade out effect. From the figure, we see that unhealthy patients quickly have their blood pressure brought into the 130 mmHg to 140 mmHg range, and their blood pressure stabilizes thereafter. We emphasize that the app plays a role in not only the initial blood pressure drop, but also the stability of the blood pressure in the long term, which is possible due to constant physician monitoring.

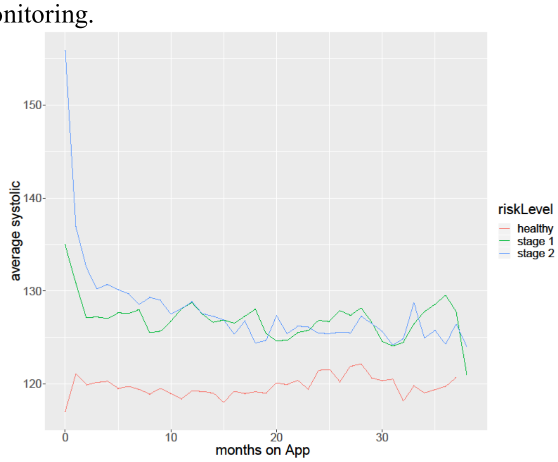

Figure 2: Blood pressure vs time on App, grouped by severity of hypertension

To test this observation more carefully, we repeat the regression estimation, replacing *nReading* with *timeOnApp*. If there is truly a fade-out effect, we would expect that the *timeOnApp* variable is insignificant in the regression since longer times on App should be associated with reduced effectiveness of the app and higher blood pressures. However, this is not the case. We find that an additional month on the app is associated with a 0.056 mmHg systolic blood pressure drop, a result significant at the 1% level. Details of this regression can be found in Table 2.

If a patient uploads more readings into the app, that patient will naturally receive more monitoring and more opportunities to communicate with the physician and his support staff. This may play an important role in explaining why the app is able to improve their health. We present some observations from our HBPM dataset now to support this hypothesis. Although these observations are only suggestive of a link between monitoring, communication, and health improvement, we feel that it is important to show these results to provide areas of focus for future research.

	Dependent variable: Systolic BP (mmHg)
	All
timeOnApp	-0.056*** (0.003)
Observations	242,437
R-sq.	0.002
Adj. R-sq	-0.002
F-stat.	410.4***

Table 2: The effect of length of app use on blood pressure.

We first measure overall patient engagement with the app by examining one particular statistic, the days between HBPM uploads for app users. Overall, we find that most patients are highly engaged with the app, with an average time between uploads of around 10 days (with a standard deviation of 21 days). To give an idea of the distribution, about 88% of patients make one upload at least once every two weeks, while 95% of patients make one upload at least once per month.

As a result of patient engagement, we hypothesize that there is more communication, either with the physician or his support staff. To estimate this level of increased communication, we calculate a new statistic that we call the "*number of potential interventions due to HBPM*" for each patient. This is the number of times that a patient has uploaded blood pressure readings over the 130-mmHg systolic limit, which is the threshold beyond which a patient is no longer classified as "healthy." Since the policy at the practice is to follow up with all patients whose readings are above this threshold, this number can be interpreted as an estimate of the number of additional times that the patient has interacted with the physician or his support staff. On average, there are 20 such potential interventions for each patient. To give an idea of the distribution, about 50% of the patients receive 5 or more potential interventions per year, and about 25% of the patients receive 23 or more potential interventions per year.

The fact that there is both a high rate of engagement and many chances for potential interventions suggests that one plausible explanation of why the app benefits patients is that these patients are in constant communication with the doctor so that any new complications in their condition are addressed immediately and in a timely manner. Another contributing factor, based on the medical literature (see Pickering, 1996; Pickering, et al., 2008) is that

HBPM readings are more accurate than OBPM readings, due to random variance and phenomena such as white-coat hypertension. By using more accurate information from HBPM readings, the doctor can make more informed decisions.

5. Discussion and Conclusion

While much of research in healthcare operations has focused on improving coordination between providers in the supply chain, we have focused on improving patient-provider coordination, an area that has received very little to no attention in the operations literature. Provider delays (partly due to infrequent face-to-face appointments) and lack of supporting infrastructure result in inferior chronic healthcare and higher costs. Technology can resolve such issues by enabling bi-directional flow of information, a crucial distinction in service supply chains. We examine the impact of such technology in this paper.

We reiterate that the effect of mHealth app comes from a combination of several factors and physician supervision plays a vital role. Our anecdotal evidence strongly points to provider-supervision as the main driver behind the benefit of mHealth apps. The app improves information flow and provides more opportunities for the provider to intervene. The app fills-in for the sporadic office visits and provides a more complete picture of the patient profile since the previous office visit. Without supervision the benefit of mHealth may greatly reduce or even be negligible.

Use of an mHealth app enables a healthcare system to be proactive and can significantly improve quality of care to underserved population. If preventive intervention can be achieved by support-staff monitoring the app, the potential contribution of mHealth apps could be very significant. In addition, using timely measurements provided by patients, a provider can customize patient care. mHealth technology therefore helps in reducing information asymmetry, improves coordination between the patient and the providers, and improves patient engagement.

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6. References

Agarwal, R., Gao, G., DesRoches, C. & Jha, A. K. (2010), 'Research commentary - the digital transformation of healthcare: Current status and the road ahead', *Information Systems Research* 21(4), 796–809.

Agnihothri, S. & Agnihothri, R. (2018), 'Application of evidence-based management to chronic disease healthcare: A framework', *Management Decision*.

Agnihothri S, Cui L, Delasay M, Rajan B. The value of mHealth for managing chronic conditions. *Health care management Science*. 2020 Jun;23(2):185-202. URL: doi.org/10.1108/MD-10-2017-1010

Agnihothri, S., Cui, L., Rajan, B., Banerjee, A., and Ramanujan, R. (2021). Mobile health application usage and quality of care at a hypertension clinic: An observational cohort study. *Journal of Hypertension*. 39(11):2265-71

Alessa, T., Abdi, S., Hawley, M. S. & de Witte, L. (2018), 'Mobile apps to support the self- management of hypertension: Systematic review of effectiveness, usability, and user satisfaction', *JMIR mHealth and uHealth* 6(7).

American Diabetes Association (2013), 'Economic costs of diabetes in the US in 2012', *Diabetes Care* 36(4), 1033–1046.

Baker, A. (2001), 'Crossing the quality chasm: a new health system for the 21st century', BMJ: *British Medical Journal* 323(7322), 1192.

Bavafa, H., Hitt, L. M. & Terwiesch, C. (2018), 'The impact of e-visits on visit frequencies and patient health: Evidence from primary care', *Management Science*. URL: https://doi.org/10.1287/mnsc.2017.2900

Brynjolfsson, E. & Yang, S. (1996), Information technology and productivity: a review of the literature, in 'Advances in Computers', Vol. 43, *Elsevier*, pp. 179–214.

CDC (2017), 'Center for Disease Control website', https://www.cdc.gov/chronicdisease/ overview/index.htm. Accessed: 2017-10-30.

Devaraj, S., Ow, T. T. & Kohli, R. (2013), 'Examining the impact of information technology and patient flow on healthcare performance: A theory of swift and even flow (TSEF) perspective', *Journal of Operations Management* 31(4), 181–192.

Dobrzykowski, D. D. & Tarafdar, M. (2015), 'Understanding information exchange in healthcare operations: Evidence from hospitals and patients', *Journal of Operations Management* 36, 201–214.

Fiala, P. (2005), 'Information sharing in supply chains', *Omega* 33(5), 419–423.

Guo, P., Tang, C. S., Wang, Y. & Zhao, M. (2019), 'The impact of reimbursement policy on social welfare, revisit rate, and waiting time in a public healthcare system: Fee-for-service versus bundled payment', *Manufacturing & Service Operations Management* 21(1), 154–170.

Ha, A. Y., Tian, Q. & Tong, S. (2017), 'Information sharing in competing supply chains with production cost reduction', *Manufacturing & Service Operations Management* 19(2), 246–262.

Hu, Q., Schwarz, L. B. & Uhan, N. A. (2012), 'The impact of group purchasing organizations on healthcare-product supply chains', *Manufacturing & Service Operations Management* 14(1), 7–23.

IHI (2010), 'Institute for Healthcare Improvement (IHI) Triple Aim Initiative'. last accessed on April 15, 2020. URL: http://www.ihi.org/Engage/Initiatives/TripleAim/Pages/default.aspx

Kanda, A., Deshmukh, S. et al. (2008), 'Supply chain coordination: perspectives, empirical studies and research directions', *International Journal of Production Economics* 115(2), 316– 335.

Kumar, N., Khunger, M., Gupta, A. & Garg, N. (2015), 'A content analysis of smartphone–based applications for hypertension management', *Journal of the American Society of Hypertension* 9(2), 130–136.

Lee, H. L., Padmanabhan, V. & Whang, S. (1997), 'Information distortion in a supply chain: The bullwhip effect', *Management Science* 43(4), 546–558.

Lee, P.M., Khong, P., Ghista, D. N. & Nata, R. N. (2006), 'Transferring best practices to healthcare: opportunities and challenges', *The TQM Magazine*.

Logan, A. G., Irvine, M. J., McIsaac, W. J., Tisler, A., Rossos, P. G., Easty, A., Feig, D. S. & Cafazzo, J. A. (2012), 'Effect of home blood pressure telemonitoring with self-care support on uncontrolled systolic hypertension in diabetics', *Hypertension* 60(1), 51–57.

Maull, R., Geraldi, J. & Johnston, R. (2012), 'Service supply chains: a customer perspective', *Journal of Supply Chain Management* 48(4), 72–86.

Milani, R. V. & Lavie, C. J. (2015), 'Health care 2020: reengineering health care delivery to combat chronic disease', *The American Journal of Medicine* 128(4), 337–343.

Parati, G., Dolan, E., McManus, R. J. & Omboni, S. (2018), 'Home blood pressure telemonitoring in the 21st century', *The Journal of Clinical Hypertension* 20(7), 1128–1132.

Pickering, T. G. (1996), 'White coat hypertension.', *Current opinion in nephrology and hyper-tension* 5(2), 192–198.

Pickering, T. G., Miller, N. H., Ogedegbe, G., Krakoff, L. R., Artinian, N. T., & Goff, D. (2008). Call to action on use and reimbursement for home blood pressure monitoring: executive summary: a joint scientific statement from the American Heart Association, American Society Of Hypertension, and Preventive Cardiovascular Nurses Association. *Hypertension*, 52(1), 1-9.

Queenan, C. C., Angst, C. M. & Devaraj, S. (2011), 'Doctors' orders - If they're electronic, do they improve patient satisfaction? A complements/substitutes perspective', *Journal of Operations Management* 29(7-8), 639–649.

Richardson, S., Hirsch, J. S., Narasimhan, M., Crawford, J. M., McGinn, T., Davidson, K. W., Barnaby, D. P., Becker, L. B., Chelico, J. D., Cohen, S. L. et al. (2020), 'Presenting characteristics, comorbidities, and outcomes among 5700 patients hospitalized with covid-19 in the New York city area', *JAMA*.

Sampson, S. E. & Spring, M. (2012), 'Customer roles in service supply chains and opportunities for innovation', *Journal of Supply Chain Management* 48(4), 30–50.

Smith, J. M. & Topol, E. (2013), 'A call to action: lowering the cost of health care', *American Journal of Preventive Medicine* 44(1), S54–S57.

Varshney, U. (2014), 'Mobile health: Four emerging themes of research', *Decision Support Systems* 66, 20–35.

Wagner, E. H., Austin, B. T., Davis, C., Hindmarsh, M., Schaefer, J. & Bonomi, A. (2001), 'Improving chronic illness care: translating evidence into action', *Health Affairs* 20(6), 64–78.

Wagner, E. H., Bennett, S. M., Austin, B. T., Greene, S. M., Schaefer, J. K. & Vonkorff, M. (2005), 'Finding common ground: patient-centeredness and evidence-based chronic illness care', *Journal of Alternative & Complementary Medicine* 11(supplement 1), s–7.

Wang, Y., Wallace, S. W., Shen, B. & Choi, T.-M. (2015), 'Service supply chain management: A review of operational models', *European Journal of Operational Research* 247(3), 685–698.

Whelton, P. K., Carey, R. M., Aronow, W. S., Casey, D. E., Collins, K. J., Himmelfarb, C. D., DePalma, S. M., Gidding, S., Jamerson, K. A., Jones, D. W. et al. (2018), '2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: A report of the American college of cardiology/American heart association task force on clinical practice guidelines', *Journal of the American College of Cardiology* 71(19), e127–e248.

York, S., Wainright, C. & Chen, D. C. (2018), 'Healthcare supply chain management: An instructive model designed to create service value', *Journal of Health Administration Education* 34(4), 525–559.

Zepeda, E. D., Nyaga, G. N. & Young, G. J. (2020), 'The effect of hospital-physician integration on operational performance: Evaluating physician employment for cardiovascular services', *Decision Sciences* 51(2), 282–316.