



# Medication Nonadherence: There's an App for That!

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*...be alert to the faults of the patients which make them lie about their taking of the medicines prescribed and when things go wrong, refuse to confess that they have not been taking their medicine.*

Hippocrates<sup>1</sup>

Several “smart” technologies have potential to change how the medical profession documents and fosters adherence to prescription medication, and if successful, the health of patients will be improved.<sup>2</sup> Yet, there are social and ethical concerns that ought to be considered before these technologies are broadly adopted, including cost and potential for coercive use. We discuss these and several other ethical and social implications of these smart technologies.

For many, modern health care entails taking prescription medications, and a broad range of conditions are treatable because of the ready availability of these medications. Prescription medications help keep people healthy and active while extending longevity and improving quality of life. Yet, many who are prescribed pharmaceuticals do not benefit.

One reason is drug nonadherence, a complex conundrum characterized by (1) **never starting** (or failing to refill) the medication, (2) **stopping** the medication regimen early without direction, or (3) regularly **not taking** the medication as directed.<sup>3</sup>

Over several decades, researchers have documented extensive nonadherence. For example, one study examined the prescription filling habits of more than 700,000 US patients who received a new prescription for one of 7 chronic illnesses. The authors found that for 6 of the illnesses, only 51% to 72% of patients filled the prescription, and for one disease (gout), just 37% had done so.

Even in Canada, where out-of-pocket medication costs tend to be lower than in

the United States, adherence is a problem. In a prospective medical record study of more than 16,000 patients in Quebec, 31% of prescriptions were never even filled.<sup>4</sup>

Nonadherence can have serious consequences—these patients are more likely to have frequent hospitalizations, more severe symptoms, and earlier death from their diseases compared with individuals who take their medications as prescribed.<sup>5,6</sup> A 2009 report estimated that avoidable medical spending due to nonadherence and poor-quality prescribing costs approximately \$289 billion per year, or 13% of total US health care expenditures.<sup>7</sup>

Myriad low-tech approaches to improving adherence have been proven effective in studies typically of short duration, including prescribing a less expensive equivalent or generic medications, telephone outreach, simplifying medication ingestion schedules, bundling medication refills simultaneously so that patients can pick up all of their medications on the same schedule, talking with patients about the importance of medications, and verifying adherence by counting inhaler puffs or checking blood levels.<sup>8-13</sup> In some disease populations (eg, patients with AIDS or tuberculosis), approaches such as text messaging, e-mail, and voice over Internet software have also been used.<sup>14,15</sup> Furthermore, e-mail, text messaging, and e-cards have been used to facilitate adherence to birth control, prenatal vitamins, and antiretroviral therapy.<sup>16</sup>

Many more attempts at solutions are in development or newly on the market. Almost 50 companies are developing software/hardware approaches to medication nonadherence, with many addressing forgetfulness or behavior modification.<sup>17-19</sup> Perhaps the most innovative are placing ingestible sensors in pills that transmit when consumed. Other

examples include “smart” medication bottles that use wireless technology to track the number of pills ingested and alarms to remind patients when a scheduled medication is due. Finally, apps (ie, applications of software programs designed to perform a specific function) for mobile devices have been developed specifically to track medication use. Notably, many of these smart solutions to medication nonadherence involve the transmission of data about the patient’s medication use to one or more third parties, for example health care professionals, caregivers, or family members, who could then intervene in real time to help ensure that the patient takes the medication.

### Potential Benefits

The aforementioned solutions to medication nonadherence and other technological innovations have the potential to improve adherence by tracking the patient, especially when the patient is motivated to take the medication as prescribed but has difficulty doing so without assistance, and when the medical team or authorized third party needs help tracking medication use to ensure compliance.<sup>20</sup> Philosophically, such innovations are consistent with the patient empowerment movement, whereby individuals are provided both the opportunity and the responsibility for being engaged in their own self-care; this process coincides with the embracement of a shared decision-making model in which patients and clinicians collaborate to understand and address patients’ needs.<sup>21-23</sup> Technologies that allow patients (rather than family and clinicians) to manage their medications with electronic reminders provide opportunities for patients to play a meaningful role in their self-care.<sup>24</sup>

These technologies may also help practitioners, who often lack accurate information about patients’ actual, rather than reported, behaviors. Specific reliable adherence data can aid practitioners’ efforts to understand why medication failed to work as predicted. For inpatients in skilled nursing facilities or other environments where medication distribution is time consuming and complex and for patients who can no longer take medication on their own, smart technologies

may also be used to audit and track consumption, thus reducing the number of health care professionals needed to monitor adherence.

At a macro level, the technology portends a potential boon to pharmaceutical researchers as well. Having more precise data about the timing and dosages being ingested may provide more accurate information about drug potency and effectiveness, with the end result of better dosing guidelines and even personalized recommendations. Additionally, access to such information serves the goals of health services researchers. For example, when combined with GPS (ie, global positioning system) data, researchers may be able to identify regions or demographic variables that predict nonadherence, which in turn can lead to targeted interventions for overcoming barriers and maximizing adherence.

In summary, smart technologies have the potential to improve patient health and reduce societal health care costs by providing tools for patients that ease the burden of taking medication. For motivated patients who embrace and use the technology, medication adherence will likely increase, suggesting that costs associated with nonadherence will be reduced over the long term.

### Potential Negative Outcomes

High-tech solutions to low-tech problems also present a variety of challenges, beginning with access. Like the ever-evolving TV remote, many people, regardless of age or demographic characteristics, are not comfortable with every digital technology and may become frustrated with the “whiz-bang” approach to what was once a simple matter of swallowing pills. A pill bottle that barks an alarm may be unpopular with people accustomed to a simple plastic container.

Second, and perhaps most important, some of the smart technologies will increase the cost of medications as pharmaceutical companies pass along the costs of imbedded sensors and alarm-integrated pill bottles to consumers. Ironically, cost is the most powerful barrier to adherence, and more patients may choose to not fill prescriptions when they are rendered more expensive.<sup>2</sup> One study on medication adherence in a community-based heart failure cohort found

that 18 patients (10%) reported not filling a new prescription because of cost, 14 (8%) stopped a medication for the same reason, and 8 (4%) skipped doses to save money.<sup>25</sup> Given that many patients with chronic illnesses take multiple medications and face serious cost concerns, it is not surprising that studies show that between 14% and 25% of patients with serious, life-threatening conditions do not fill needed prescriptions.<sup>26-29</sup> Studies have also revealed that fewer than 66% of patients tell their physician when they plan to underuse medications because of cost, and fewer than 30% of physicians ask patients about the affordability.<sup>30,31</sup> So even if the smart technologies enhance medication adherence for those who use them, the added cost of implementation may have the paradoxical effect of reducing access to patients for whom purchasing medication is already a financial barrier.

Third, patient nonadherence is sometimes smart. For example, when an angiotensin-converting enzyme inhibitor prescribed as kidney protective for a person with chronic kidney disease causes severe vomiting and diarrhea—risking dehydration and hypotension—it is reasonable to stop taking the drug until a discussion with a physician is possible. Inevitably, some medications are ineffective or induce troubling adverse effects. Prompts designed to blindly promote adherence could pressure a person to tolerate noxious adverse effects to stop harassment from digital devices. In a digitally tracked world, there may be less room for educated nonadherence.

Fourth, we fear the temptation to stratify patients according to their risk of nonadherence and then use the information for discriminatory purposes. If patients are assigned adherence scores like credit scores, payers would be armed with data that can be used to ration care or otherwise penalize nonadherent patients by charging higher deductibles, adding surcharges, or refusing to insure them. *International Classification of Diseases, Tenth Revision* coding already allows for nonadherence labeling (Code V15.81), and studies have found an association between such codes and mortality.<sup>5</sup> It is not a settled matter whether it is fair to charge people more for their medical care based on adherence to recommendations (or other unhealthy

behaviors).<sup>32,33</sup> Thus, it is important to better understand both how the information will be used and the underlying ethical rationale for doing so before unleashing these tools outside carefully controlled environments.

Fifth, even if monitoring patient behaviors would lead to better health outcomes and lower costs, it is not clear whether or whom we should empower to enforce health behaviors. Although physicians have a fiduciary responsibility to prioritize patients' interests over other considerations, this is not generally understood as an endorsement for unduly pressuring patients to take medications as prescribed (except with court orders or in settings such as inpatient psychiatry or certain quarantine situations). These smart technologies will make adherence data available not only to physicians but also to other parties who have no such fiduciary relationships with patients (and who, in fact, may be beholden to others).<sup>17,34</sup> The diagnostic assessment that a patient is not taking a medicine as prescribed can easily lead to a prescriptive "should," which is not far removed from the coercive "must." The availability of adherence data and the tools of enforcement potentially empower these parties to compel individuals to take specific medications and track their use from afar, effectively cutting the patient out of information exchange and flipping the long-standing tradition of prioritizing patient autonomy over the interests of others.

Finally, we worry that these smart technologies may be "quick fixes" preferred to simpler, time-intensive, but already proven effective interventions such as talking with patients, identifying supports in their lives who can help them take medications as intended, bundling multiple medications so they are ingested at the same time, and medication reconciliations to remove unneeded medications.

### Concerns and Recommendations

Adherence-monitoring technologies have some attractive features—they can alert health care professionals to patterns of adherence in individuals or groups and they can remind patients to take medications as prescribed. Prescribers and health care systems may be attracted to these smart technologies because they provide real-time data about ingestion

of medications without being labor intensive. Yet, some could lead to higher medication costs or be used paternalistically to compel patients to take medications they do not want to take.

As reimbursement models shift from fee-for-service to population management, large-scale efforts to improve adherence will likely intensify. It remains to be seen if smart technologies are the most effective, cost-efficient, and ethical way to accomplish this goal. No doubt they may work well for some patients, and we hope that future studies will identify the most appropriate settings for using these technologies. Regardless of whether smart technology is used, good prescribing practice ought to involve ordering the least expensive yet effective medications available while providing sufficient counseling for patients to understand the importance of adherence. In keeping with this ethos, medication regimens should be kept as simple as possible, and unnecessary drugs should be eliminated. Further, prescriptions should be bundled and refilled for the maximum duration possible to ensure that patients don't run out.<sup>35-38</sup>

If smart technologies are used to collect data about patient adherence, we must ask the ethical question, "Toward what end will these data be used?" The interests of patients, health care systems, pharmaceutical companies, insurers, and physicians (to name but a few prominent players) are not always aligned and can in fact be at odds. It is important to address what (if anything) would justify prioritizing the well-being of third parties over that of patients and what assurances will be put in place so that clinical information from adherence data and monitoring will be used to prioritize the interests of patients over the financial or other interests of third parties.

### Conclusion

Smart technologies have the potential to help improve adherence to medical recommendations. However, we can only speculate about some of the unintended consequences of their use. For now, we encourage more studies not only on biological effectiveness but also on cost, access, and how the information is used and by whom. Continued empirical evaluation will allow us to better understand the

implications for stigmatization, patient autonomy, privacy, and fiduciary conflicts of interest.

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### REFERENCES

1. Hippocrates. *Decorum*. c. 200 BC.
2. Epstein RS. Medication adherence: hope for improvement [editorial]? *Mayo Clin Proc*. 2011;86(4):268-270.
3. Jimmy B, Jose J. Patient medication adherence: measures in daily practice. *Oman Med J*. 2011;26(3):155-159.
4. Tamblyn R, Equale T, Huang A, Winslade N, Doran P. The incidence and determinants of primary nonadherence with prescribed medication in primary care: a cohort study. *Ann Intern Med*. 2014;160(7):441-450.
5. Gosmanova EO, Lu JL, Streja E, Cushman WC, Kalantar-Zadeh K, Kovesdy CP. Association of medical treatment nonadherence with all-cause mortality in newly treated hypertensive US veterans. *Hypertension*. 2014;64(5):951-957.
6. Ho PM, Rumsfeld JS, Masoudi FA, et al. Effect of medication nonadherence on hospitalization and mortality among patients with diabetes mellitus. *Arch Intern Med*. 2006;166(17):1836-1841.
7. New England Healthcare Institute. Thinking outside the pillbox: a system-wide approach to improving patient medication adherence for chronic disease. NEHI Research Brief. New England Healthcare Institute website, [http://www.nehi.net/writable/publication\\_files/file/pa\\_issue\\_brief\\_final.pdf](http://www.nehi.net/writable/publication_files/file/pa_issue_brief_final.pdf). Published August 2009. Accessed August 14, 2017.
8. Shrank WH, Hoang T, Ettner SL, et al. The implications of choice: prescribing generic or preferred pharmaceuticals improves medication adherence for chronic conditions. *Arch Intern Med*. 2006;166(3):332-337.
9. O'Connor PJ, Schmittiel JA, Pathak RD, et al. Randomized trial of telephone outreach to improve medication adherence and metabolic control in adults with diabetes. *Diabetes Care*. 2014;37(12):3317-3324.
10. Leguelinel-Blanche G, Dubois F, Bouvet S, et al. Improving patients' primary medication adherence: the value of pharmaceutical counseling. *Medicine (Baltimore)*. 2015;94(41):e1805.
11. Sinsky C, Moran B. Prescription renewals and medication adherence [letter]. *Health Aff (Millwood)*. 2016;35(11):2151.
12. Thom DH, Willard-Grace R, Hessler D, et al. The impact of health coaching on medication adherence in patients with poorly controlled diabetes, hypertension, and/or hyperlipidemia: a randomized controlled trial. *J Am Board Fam Med*. 2015;28(1):38-45.
13. Kelloway JS, Wyatt RA, Adlis SA. Comparison of patients' compliance with prescribed oral and inhaled asthma medications. *Arch Intern Med*. 1994;154(12):1349-1352.
14. World Health Organization. Handbook for the Use of Digital Technologies to Support Tuberculosis Medication Adherence.

- World Health Organization website, [www.who.int/tb/publications/2018/TB\\_medication\\_adherence\\_handbook\\_2018/en/](http://www.who.int/tb/publications/2018/TB_medication_adherence_handbook_2018/en/). Published January 2018. Accessed May 8, 2018.
15. Horvath T, Azman H, Kennedy GE, Rutherford GW. Mobile phone text messaging for promoting adherence to antiretroviral therapy in patients with HIV infection. *Cochrane Database Syst Rev*. 2012;(3):CD009756.
  16. Castaño PM, Stockwell MS, Malbon KM. Using digital technologies to improve treatment adherence. *Clin Obstet Gynecol*. 2013;56(3):434-445.
  17. Waltz E. Drugs go wireless. *Nat Biotechnol*. 2016;34(1):15-18.
  18. Gebremedhin D, Werner K. Medication adherence tech: a dynamic and crowded market, but where are the winners in the space? (part 1 of 2). *MobiHealthNews* website, [www.mobihhealthnews.com/content/medication-adherence-tech-dynamic-and-crowded-market-where-are-winners-space-part-1-2](http://www.mobihhealthnews.com/content/medication-adherence-tech-dynamic-and-crowded-market-where-are-winners-space-part-1-2). Published August 25, 2017. Accessed February 26, 2018.
  19. Arya V, Alam R, Zheng M. Medication adherence: there's an app for that. *APhA* website, <http://www.pharmacist.com/medication-adherence-there%E2%80%99s-app>. Published June 1, 2013. Accessed August 1, 2017.
  20. Belluck P. First digital pill approved to worries about biomedical "Big Brother". *The New York Times* website, <https://www.nytimes.com/2017/11/13/health/digital-pill-fda.html>. Published November 13, 2017. Accessed May 8, 2018.
  21. Johnston Roberts K. Patient empowerment in the United States: a critical commentary. *Health Expect*. 1999;2(2):82-92.
  22. Bodenheimer T, Lorig K, Holman H, Grumbach K. Patient self-management of chronic disease in primary care. *JAMA*. 2002;288(19):2469-2475.
  23. Kunneman M, Montori VM, Castaneda-Guarderas A, Hess EP. What is shared decision making? (and what it is not). *Acad Emerg Med*. 2016;23(12):1320-1324.
  24. Preusse KC, Mitzner TL, Fausset CB, Rogers WA. Older adults' changes in intent to adopt wellness management technologies. *Proc Human Factors Ergonomics Soc*. 2014;58(1):200-204.
  25. Dunlay SM, Eveleth JM, Shah ND, McNallan SM, Roger VL. Medication adherence among community-dwelling patients with heart failure. *Mayo Clin Proc*. 2011;86(4):273-281.
  26. Cheetham TC, Niu F, Green K, et al. Primary nonadherence to statin medications in a managed care organization. *J Manag Care Pharm*. 2013;19(5):367-373.
  27. Steinman MA, Sands LP, Covinsky KE. Self-restriction of medications due to cost in seniors without prescription coverage. *J Gen Intern Med*. 2001;16(12):793-799.
  28. Cooke CE, Xing S, Lee HY, Belletti DA. You wrote the prescription, but will it get filled? *J Fam Pract*. 2011;60(6):321-327.
  29. Kitchman M, Neuman T, Sandman D, Schoen C, Safran D, Montgomery J. Seniors and Prescription Drugs—Findings from a 2001 Survey of Seniors in Eight States. The Commonwealth Fund and Tufts-New England Medical Center; Washington, DC: The Henry J. Kaiser Family Foundation, 2002, [http://www.commonwealthfund.org/~media/files/publications/fund-report/2002/jul/seniors-and-prescription-drugs—findings-from-a-2001-survey-of-seniors-in-eight-states/safran\\_seniors.pdf](http://www.commonwealthfund.org/~media/files/publications/fund-report/2002/jul/seniors-and-prescription-drugs—findings-from-a-2001-survey-of-seniors-in-eight-states/safran_seniors.pdf). Accessed October 2, 2017.
  30. Piette JD, Heisler M, Wagner TH. Cost-related medication underuse: do patients with chronic illnesses tell their doctors? *Arch Intern Med*. 2004;164(16):1749-1755.
  31. Mazer M, Bisgaier J, Dailey E, et al. Risks for cost-related medication nonadherence among emergency department patients. *Acad Emerg Med*. 2011;18(3):267-272.
  32. Feiring E. Lifestyle, responsibility and justice. *J Med Ethics*. 2008;34(1):33-36.
  33. Buyx AM. Personal responsibility for health as a rationing criterion: why we don't like it and why maybe we should. *J Med Ethics*. 2008;34(12):871-874.
  34. Caplan A. Would you take a 'digital' pill? bioethicist warns about privacy risk. *NBC News* website, <http://www.nbcnews.com/health/health-news/bioethicist-digital-snitch-pill-may-destroy-our-medical-privacy-n430091>. Published September 18, 2015. Accessed July 29, 2017.
  35. Ax F, Brånstad JO, Westerlund T. Pharmacy counselling models: a means to improve drug use. *J Clin Pharm Ther*. 2010;35(4):439-451.
  36. Coleman CI, Limone B, Sobieraj DM, et al. Dosing frequency and medication adherence in chronic disease. *J Manag Care Pharm*. 2012;18(7):527-539.
  37. Caldeira D, Vaz-Carneiro A, Costa J. The impact of dosing frequency on medication adherence in chronic cardiovascular disease: systematic review and meta-analysis. *Rev Port Cardiol*. 2014;33(7-8):431-437.
  38. Winter MC, Halpern M, Brozovich A, Neu N. Evaluation of an HIV adherence counseling program in La Romana, Dominican Republic. *J Int Assoc Provid AIDS Care*. 2014;13(4):361-365.