Undergraduate Thesis Prospectus

# Redesigning the Incentive Spirometer

(technical research project in Biomedical Engineering)

# Patient Care at Home: Fighting Deficient Medication Adherence Outside of Hospitals and Clinics

(sociotechnical research project)


by

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October 27, 2022


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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

*Wendy Lin*

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| *STS advisor*: | Peter Norton, Department of Engineering and Society |

## General research problem

*How can patient care be improved?*

Health conditions have major implications on human lives, such as affecting their quality of life or even leading to their demise. Several of them, such as heart diseases and cancer, are leading causes of death. Excellent patient care can heavily influence health outcomes and lead to better recovery and improvements in both the mental and physical well-being of patients. Advances in patient care are critical to fighting health conditions. This includes not only the development of new medicines and treatments but also ensuring that patients have a healthy relationship with existing treatments.

## Redesigning the Incentive Spirometer

*How can patient adherence to the IS be improved through gamification?*

My advisor for my biomedical engineering capstone project is Dr. Masahiro Morikawa, affiliated with Family Medicine at the UVA Hospital, and I am collaborating with Chioma Illoh and Megan Bower. Rather than making a new design entirely, we are hoping to add a modification to the existing device.

The incentive spirometer (IS) is a medical device that prevents respiratory complications by enabling a complete filling of the lungs, which helps prevent the buildup of fluid and decrease the risk of infections. The goal is to create a new design that will raise patient adherence to the device by making the design more fun and engaging in a process known as gamification, which is the process of incorporating game-like elements into things not associated with games.

In terms of function, the current IS device has no flaws and performs well (Google Patents, 1983). The main concern is that patient adherence to the IS is poor due to its boring and

unmotivating design. We believe that the psychological impact of gamification will lead to better engagement by stimulating people's instinct for exploration and curiosity. Our design will utilize gamification as positive reinforcement to boost patients' adherence to the IS. There have been efforts to gamify the IS before, like the ZEPHYRx Gamified Incentive Spirometry, but that study is still in progress, and there are many opportunities for other alternatives. (ClinicalTrials, 2020).

We plan to come up with several prototype designs by the end of the semester and survey patients for their feedback on them in the spring. Our device must be simple, user-friendly, lightweight, and durable. Our target audience is adults over the age of 50, and because we do not fit in that demographic, there will be some difficulty in determining which design idea will be most engaging to them.

During our prototyping phase, we will ask our advisor for his opinions and input before settling on a final design. Then, we will arrange clinical testing with our advisor to receive feedback from patients and caregivers. The feedback will be our main data, and we plan to collect information on adherence rate and have the patients rank the quality of the device on a scale of 1 to 10. After the clinical testing phase, we plan to perform statistical analysis on our data to compare the adherence rate and the quality of service of our new IS device to the current IS device. If our device performs well, we are planning to have it patented, FDA approved, and potentially look into manufacturing it or selling it to a company.

**Patient Care at Home: Fighting Deficient Medication Adherence Outside of Hospitals and Clinics**

*In the U.S., how are physicians and other healthcare providers striving to promote patients' medication adherence outside of hospitals and clinics?*

Medication adherence is the act of taking medication correctly concerning time, dosage, and frequency. It plays a critical role in improving patient health, so medical professionals aim for good medication adherence among their patients. However, many patients do not take their medication properly, leading to subpar outcomes, more hospital admissions, higher healthcare costs, and increased morbidity and mortality (Ebeywa et al., 2021; Peacock, 2021). Deficient medication adherence is a big problem in healthcare, and it may have various causes, from unaffordability to unwanted side effects. The issue is worse outside of hospitals and clinics where it is more difficult for medical professionals to monitor the patients (Bouwman et al., 2017).

One attempt to boost medication adherence was through the psychology of gamification. Researchers explored how healthcare games can be structured to help with treatments and monitor patients' treatment (Armstrong, 2014). It is proven to be effective in having more consistent treatment adherence and a faster rate of self-efficiency in patients. However, the healthcare game industry is slow to progress. There is also little research on gamification in healthcare despite its potential as well as controversy on how video game addiction might lead to a sedentary lifestyle.

From the medical professionals' standpoint, they wanted patients to take their medication properly (Kim, n.d.). They want to promote a "trusting and effective relationship between patient and practitioner" by maintaining a blame-free environment and praising goal achievements. The healthcare team and administrators are also trying to boost medical adherence with effective intervention and better engagement toward patients.

For pharmaceutical companies, a source from Pfizer shows that they also encourage proper adherence to medication (Pfizer, n.d.). Pharmaceutical companies would implement

strategies such as partnering with pharmacies, offering financial assistance programs, and utilizing smart data to improve patient support (Schultz, 2022). It is also possible that pharmaceutical companies want to increase medication adherence because it will bring higher profits.

One participant group is people who want to increase medication adherence by making medication more affordable. Burdened by medication expenses, Bernetha Patterson (2022) wrote: “My children have their own families to take care of; they shouldn’t have to pay for me because Medicare won’t.” Patterson resorted to “forgoing filling my prescription this month.” She admitted: “I don’t know what will happen, but I know purchasing my medication is simply not an option.” Patients For Affordable Drugs is an independent organization that advocates for patients like Patterson (PFAD, 2022). They aim to educate the public about how drug corporations monopolize the drug market and raise drug prices. The organization helped pass the Inflation Reduction Act, which limited price gouging on existing drugs, and they are now fighting to do the same for newer drugs. Their goal is to achieve accessibility and affordability for patients while meeting the need for fair profits.

Another participant group is patients who are negligent and often misused medication due to forgetting to take them or misreading the instructions (Dijkstra et al., 2020). One patient said, “So, I have medications for 12 o'clock, but when I sleep at that time and wake up at let's say 12.30 o'clock, it is too late to take it. Someone told me to not take the medications when the intake moment has passed, so I don't take the pills.” Another patient admitted, “I don't know the rules, I stir all pills in a glass of water and when they are mixed, I drink the water.” Other cases of negligence include taking expired medication because patients misread the expiration date or forgot about it.

The last participant group is patients who choose not to take their medication for reasons such as avoiding medication overload or side effects. Medication overload is when the use of multiple drugs ended up causing more harm than benefit to the patient. A patient in this group wrote a blog about their experience and explained, “I’d been on four, definitely over-medicated ... I was starting to feel disillusioned and was tired of relying on chemistry to function. I was feeling blunted, unable to feel much of anything at all.” (Kat, 2015) Another patient stopped taking his medication due to side effects: “I don’t use the furosemide anymore; I don’t have any problems with urinating anymore. I didn’t ask the physician if I could stop using the medications.”

## References


Armstrong, S. (2014, Sep.) Video games on prescription. *BMJ: British Medical Journal*. Jstor

Bouwman, L., Eeltink, C. M., Visser, O., Janssen, J. J. W. M., & Maaskant, J. M. (2017, Nov. 9). Prevalence and associated factors of medication non-adherence in hematological-oncological patients in their home situation. *BMC cancer*. BioMed Central

ClinicalTrials. (2020, Jun. 11). A randomized control trial of zephyrx gamified incentive spirometry compared to traditional spirometry. clinicaltrials.gov/ct2/show/NCT04429009

Dijkstra, N. E., Sino, C. G. M., Schuurmans, M. J., Schoonhoven, L., and Heerdink, E. R. (2020, Sep. 16). Medication self-management: Considerations and decisions by older people living at home. *Research in Social and Administrative Pharmacy.* www.sciencedirect.com/science/article/pii/S1551741120300085

Ebeywa, E.; Gruss, V.; and Koronkowski, M. (2021, Nov. 1). Promoting a Shared Medication Adherence Practice: A Call to Action. ClinicalKey

Google Patents. (1983, Jul. 5). US4391283A - incentive spirometer. patents.google.com/patent/US4391283A/en

Kat (2015, Nov. 12). Why I quit taking my medications. *You Matter*. youmatter.988lifeline.org/why-i-quit-taking-my-medications/

Kim, J. P. D. (2018, Jan. 19). Medication adherence: The elephant in the room. *U.S. Pharmacist*. www.uspharmacist.com/article/medication-adherence-the-elephant-in-the-room

Patterson, B. (2022, Sep. 27). Opinion: With the inflation reduction act, I won't have to skip filling my prescription. *The American Independent*. americanindependent.com/opinion-inflation-reduction-act-prescription-drugs-costs-copays-joe-biden

Peacock, E; Joyce, C; Craig, L.S.; Lenane, Z.; Holt, E.W.; et al. (2021, Jan.). Low medication adherence is associated with decline in health-related quality of life: results of a longitudinal analysis among older women and men with hypertension. Medline ProQuest

PFAD (2022, Sep. 2). Patients For Affordable Drugs. Solutions. patientsforaffordabledrugs.org/solutions

Pfizer (n.d.). The value of drug adherence. cdn.pfizer.com/pfizercom/health/VOM_DrugAdherence.pdf

Schultz, D. L. (2022, Jun. 9). Improving medication adherence to specialty drugs. *AllazoHealth.* allazohealth.com/resources/improving-medication-adherence-to-specialty-drugs/#:~:text=In%20many%20cases%2C%20pharmaceutical%20companies,to%20support%20patients%20and%20caregivers.