

## Modeling Adherence to Diabetes Mellitus Treatment

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The burden of Diabetes Mellitus (DM) has been rising over the past few decades, primarily driven by the continuous increase in the incidence of Type 2 DM (T2DM) cases [1]. In 2021, there were around 537 million people aged between 20-79 years with DM globally, and about 80% of this population resided in low-and middle-income countries (LMICs) [2]. DM is projected to affect 783.2 million individuals by 2045 [3].

World Health Organization recommends a comprehensive approach to the clinical management of T2DM, including pharmacological and non-pharmacological interventions targeting glycemic control [4-6]. However, medication non-adherence remains prevalent among individuals with DM, which is associated with adverse outcomes [7] and a high risk of severe complications, including heart disease, stroke, end-stage renal disease, vision loss, and foot gangrene[8]. Effective adherence to T2DM treatment extends beyond taking prescribed medications and requires consistent self-monitoring, compliance with a healthy diet, and engagement in an active physical lifestyle. Patients often struggle to adhere to these self-management behaviors, leading to negative health outcomes such as suboptimal therapeutic outcomes, financial burden, and increased risk of morbidity and mortality [7, 9, 10]. Non-adherence to treatment is particularly higher in LMICs, where limited access to medicines and medical equipment, as well as poor awareness and health education persist.

A few studies have previously conducted simulation models for DM, incorporating model structures for pre-DM diagnosis, DM, and DM with complications diagnosis to project the growth in DM prevalence trends and test some interventions [11-14]. However, the findings of a realist review (the ongoing study of my PhD project) showed that some interventions, such as mHealth and eHealth implementation effectively improve treatment adherence and glycemic control in LMICs. Thus, a simulation model is developed to achieve the following objectives:

- To examine the influence of treatment adherence on the incidence of complications
- To test the impact of health interventions aimed at improving access to healthcare services and self-management on treatment adherence

An overview of the underlying causal effects through a causal loop diagram is shown in Figure 1.

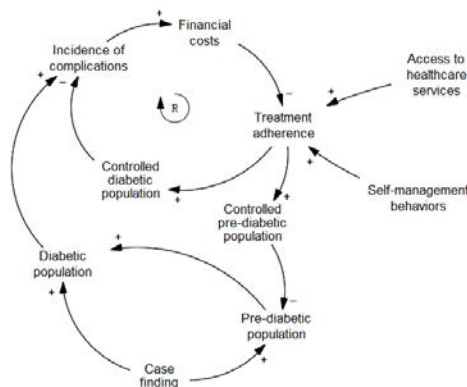


Figure 1 - A causal loop diagram on the dynamics of treatment adherence

**Commented [HR1]:** This is a good problem and your background notes are clear, so now you want to focus on clarifying the problem definition. I think you can focus on building the stock and flow backbone of your model of DM, without worrying too much about broader feedbacks, such as those in your figure. Specifically, 1) getting a stock and flow structure with Healthy, Pre-diabetic, DM without complications, and DM with complications would give you a good starting point. Once you formulate and test that, you can 2) go through another step where each stock can be subscripted for demographic features that matter in the dynamics (age/socio-economic state/gender?). Your main task is to build a solid model with fractional rates for all the transitions between states and deaths, 3) trying to put the model in equilibrium for a fixed population. You can then 4) consider different interventions and how they may impact the transition rates for each population group. I think if you do the first and perhaps the second task, you have done plenty for the course.

## References

1. Forouhi, N.G. and N.J. Wareham, *Epidemiology of diabetes*. Medicine, 2019. **47**(1): p. 22-27.
2. Rahim, N.E., et al., *Diabetes risk and provision of diabetes prevention activities in 44 low-income and middle-income countries: a cross-sectional analysis of nationally representative, individual-level survey data*. Lancet Glob Health, 2023. **11**(10): p. e1576-e1586.
3. Federation, I., *IDF Diabetes Atlas, 9th edn*. 2019.
4. Organization, W.H., *Hearts: technical package for cardiovascular disease management in primary health care: risk-based CVD management*. 2020: World Health Organization.
5. Organization, W.H., *WHO package of essential noncommunicable (PEN) disease interventions for primary health care*. 2020.
6. Flood, D., et al., *The state of diabetes treatment coverage in 55 low-income and middle-income countries: a cross-sectional study of nationally representative, individual-level data in 680&#x2009;102 adults*. The Lancet Healthy Longevity, 2021. **2**(6): p. e340-e351.
7. Ho, P.M., et al., *Effect of Medication Nonadherence on Hospitalization and Mortality Among Patients With Diabetes Mellitus*. Archives of Internal Medicine, 2006. **166**(17): p. 1836-1841.
8. Sharma, D., et al., *Medication Adherence and its Predictors among Type 2 Diabetes Mellitus Patients: A Cross-Sectional Study*. Indian J Community Med, 2023. **48**(5): p. 781-785.
9. Sokol, M.C., et al., *Impact of Medication Adherence on Hospitalization Risk and Healthcare Cost*. Medical Care, 2005. **43**(6).
10. Unni, E.J., S. Gupta, and N. Sternbach, *Trends of self-reported non-adherence among type 2 diabetes medication users in the United States across three years using the self-reported Medication Adherence Reasons Scale*. Nutrition, Metabolism and Cardiovascular Diseases, 2022. **32**(1): p. 151-159.
11. Jones, A.P., et al., *Understanding diabetes population dynamics through simulation modeling and experimentation*. American journal of public health, 2006. **96**(3): p. 488-494.
12. Mishra, V., C. Samuel, and S. Sharma, *System modeling for forecasting of diabetes prevalence*. Indian Journal of Public Health Research & Development, 2018. **9**(7).
13. Li, H., et al., *System dynamic model simulates the growth trend of diabetes mellitus in Chinese population: implications for future urban public health governance*. International Journal of Public Health, 2022. **67**: p. 1605064.
14. Homer, J., et al. *The CDC's diabetes systems modeling project: developing a new tool for chronic disease prevention and control*. in 22nd International Conference of the System Dynamics Society. 2004.

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