IOCMA 2026 Conference

The 2nd International Online Conference on Mathematics and Applications

10–12 June 2026 | Online

MDPI

Impacts of Time-Varying Aspiration on Vaccination Behaviour and Epidemic Control

Anika Rahman Shapnil*

Department of Mathematics, University of Dhaka, Bangladesh

INTRODUCTION

Vaccination behavior plays a crucial role in determining epidemic outcomes. Recent studies have shown that aspiration-based decision making can improve vaccine uptake and reduce the social efficiency deficit (SED). However, most existing models assume that aspiration remains constant over time. In reality, individuals often become more motivated to vaccinate during outbreaks and less motivated when perceived risk declines. To address this limitation, we investigate the effects of time-varying aspiration within a SEIRS vaccination game framework.

OBJECTIVES

The objective of this study is to examine how dynamic aspiration influences vaccination behavior and epidemic control. Specifically, we compare:

- **Constant aspiration** (baseline model)
- **Prevalence-driven aspiration**, where aspiration increases with disease prevalence
- **Time-decaying aspiration**, where aspiration gradually decreases over time

The impacts of these mechanisms are evaluated using infection prevalence, vaccination coverage, cumulative infections, and the social

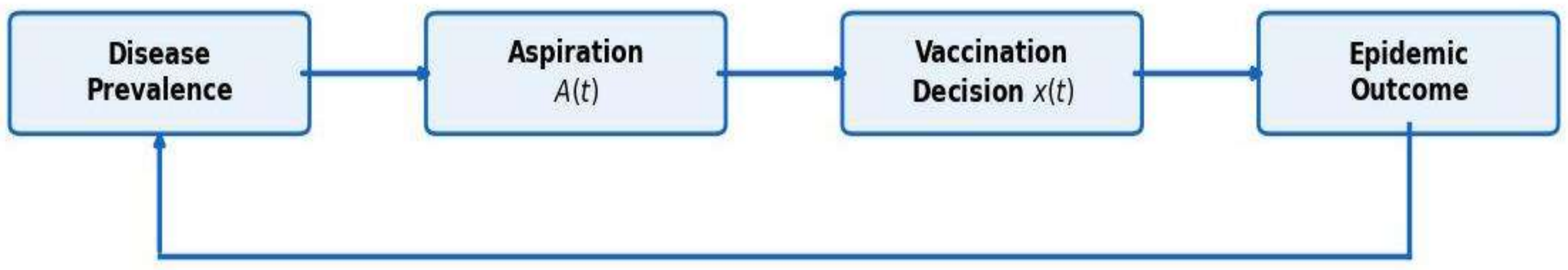

Figure 1: Behavior–epidemic feedback mechanism

METHOD

A SEIRS vaccination game model with compartments ***S, V, E,*** I_A, I_S, and ***R*** used to study dynamic aspiration.

Vaccination Dynamics:.

$$\frac{dx}{dt} = mx(1-x)(A(t) - R_s)$$

where, x(t) denotes vaccination rate, A(t) represents the aspiration level, and R_s is the perceived vaccination payoff.

Three aspiration mechanisms were investigated to capture different patterns of vaccination motivation.

Mechanism	Aspiration Function
Constant	$A(t) = A_0$
Prevalence-driven	$A(t) = A_0 + \alpha_A(I_A + I_S)$
Time-decaying	$A(t) = A_0 e^{-\delta t}$

Table 1: Dynamic aspiration mechanisms

Symbol	Meaning
A_0	Baseline aspiration
α_A	Prevalence response strength
δ	Aspiration decay rate

Table 2: Key Model Parameters

Metric	Interpretation
$I_A + I_S$	Total infectious prevalence
$x(t)$	Vaccination behavior
$IT = \int_0^T \alpha E(t)dt$	Cumulative infections
$ASP = -C_V VT - C_I IT$	Average social payoff
$SED = ASP_{SO} - ASP_{NE}$	Social efficiency deficit

***Table 3*:** Evaluation Metrics

RESULTS & DISCUSSION

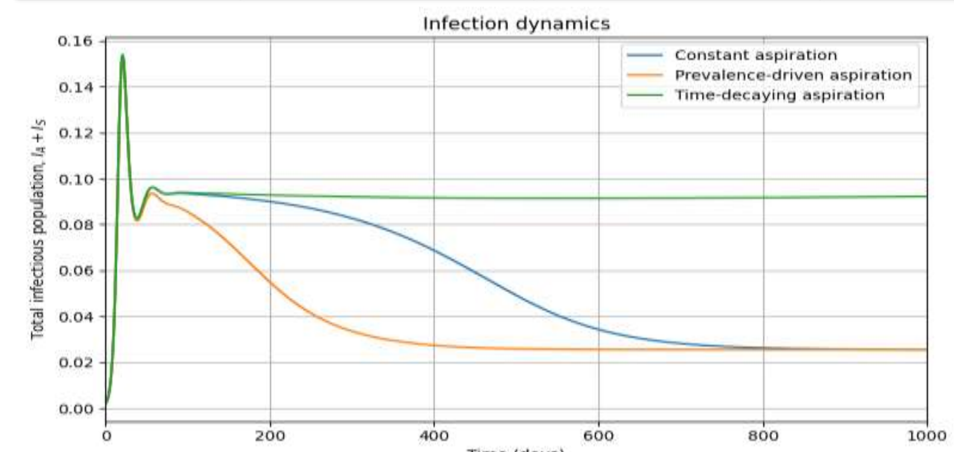

Figure 2:Prevalence-driven aspiration reduced infection levels more rapidly, while time-decaying aspiration resulted in sustained disease prevalence.

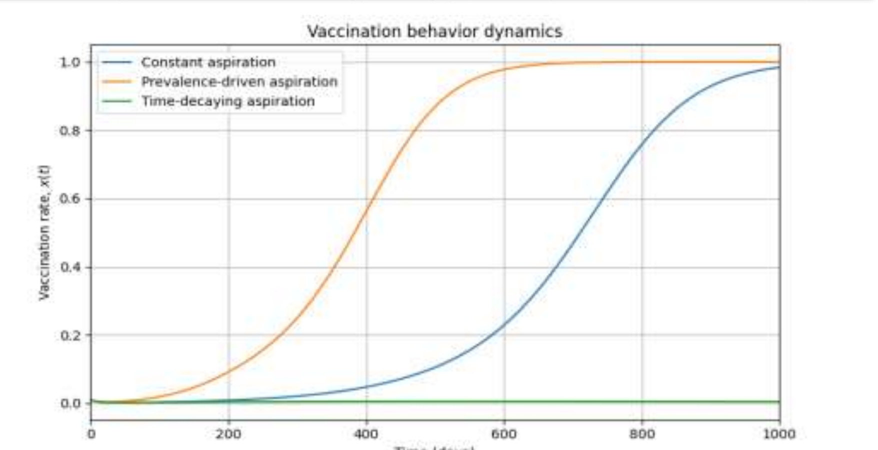

Figure 3: Prevalence-driven aspiration accelerated vaccine uptake, whereas time-decaying aspiration suppressed long-term vaccination coverage.

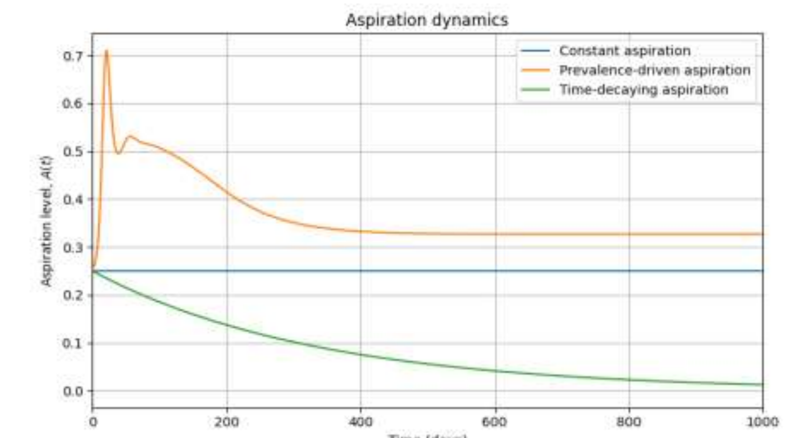

Figure 4: Aspiration increased with disease prevalence but declined gradually under the time-decaying mechanism

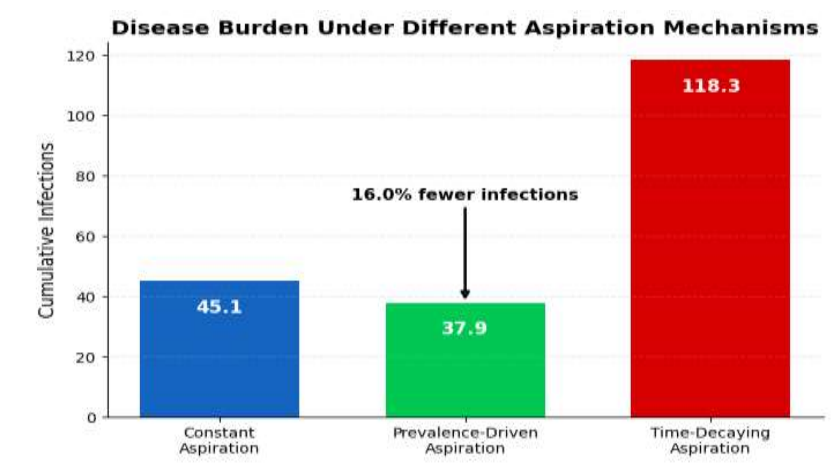

Figure 5: Prevalence-driven aspiration reduced cumulative infections by 15.9% relative to constant aspiration

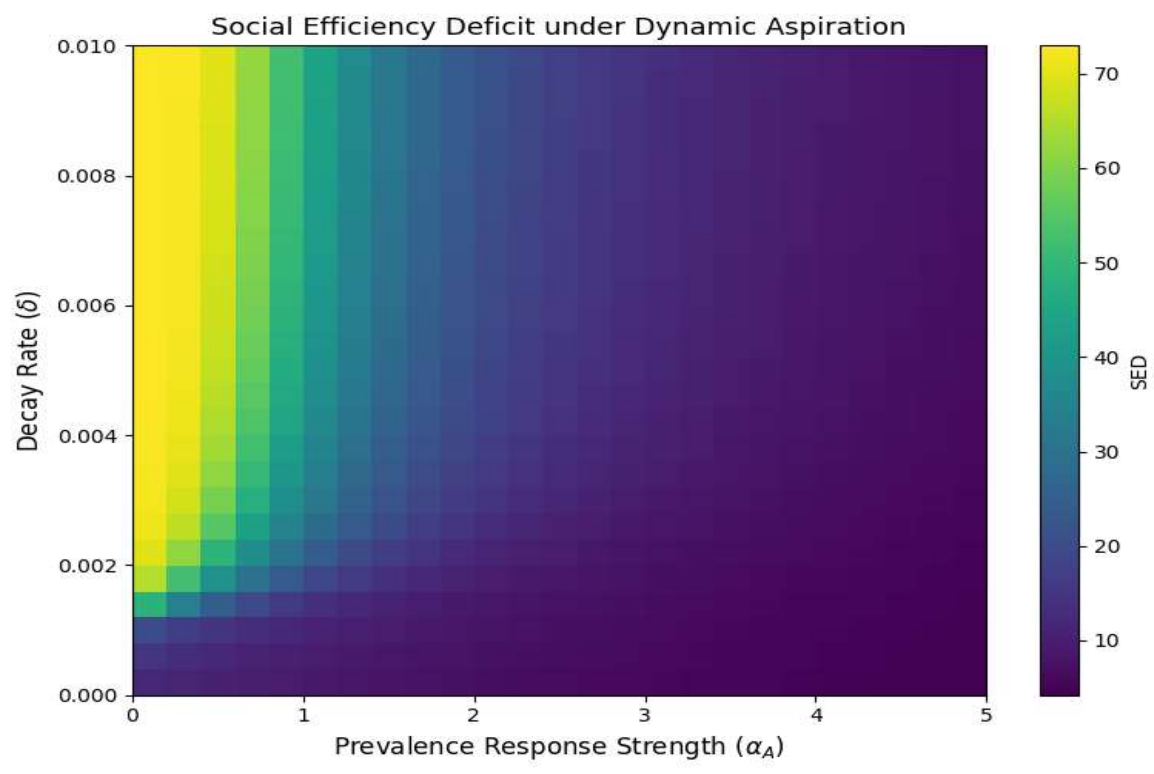

Figure 6: SED decreases with increasing prevalence responsiveness and decreasing aspiration decay. The lowest SED values occur when aspiration remains responsive to disease prevalence, while rapid aspiration decay increases social inefficiency

CONCLUSION

- Prevalence-driven aspiration improved epidemic control.
- Time-decaying aspiration increased disease burden.
- Sustaining aspiration improved social efficiency and epidemic control.

FUTURE WORK

- Network-based vaccination dynamics
- Heterogeneous populations
- Data-driven model validation