A Dynamic Model of Workforce Management During Seasonal Epidemics

Ahmet Emir Şener[a] Gönenç Yücel[a]

Department of Industrial Engineering, Boğaziçi University[a]

04 August 2025

Overview

Introduction

- **Challenge:** Seasonal epidemics pose significant threats to organizational stability by reducing workforce availability and disrupting operational continuity
- **Workplace Transmission:**
  - 20-25% of daily interpersonal contacts occur at work [1]
  - Workplaces account for ∼1/3 of community influenza transmissions [1]
  - Infection prevalence can reach 14.3% among working-age adults [2]
- **Presenteeism Problem:** 60-80% of symptomatic workers attend work, accelerating transmission [3]
- **Economic Impact:** 111 million lost workdays annually ($7 billion in losses) [4]

Problem Definition

- **Workplace as Infection Epicenters:**
  - Rapid transformation into disease propagation centers [5]
  - Symptomatic employees with presenteeism accelerate transmission, compounding labor shortages and operational instability
- **Critical Trade-off:**
  - **High Absenteeism:** Direct production capacity losses
  - **High Presenteeism:** Amplified disease transmission affecting larger workforce
- **Management Challenge:**
  - Balance health-related risks vs. workforce capacity losses
  - Mitigate disease transmission while maintaining operational continuity
- **Need:** Targeted managerial interventions adapted to workplace culture and epidemic characteristics

Objectives

- **Primary Objective:** Investigate and evaluate managerial policies for workforce management during seasonal influenza-like epidemics
- **Understanding Workforce Dynamics:**
  - Different epidemic scenarios and infectivity profiles
  - Regional and cultural variations in sick-leave practices
- **Dynamic Model for Workforce Management:**
  - Simulate alternative managerial interventions
  - Strategic decision-making tool for organizations
  - Evaluate the impacts of alternative managerial interventions on workforce availability and capacity
- **Outcomes:** Actionable recommendations to enhance organizational resilience and maintain workforce performance during seasonal epidemic disruptions

Seasonal Epidemic Model - Causal Loop Diagram

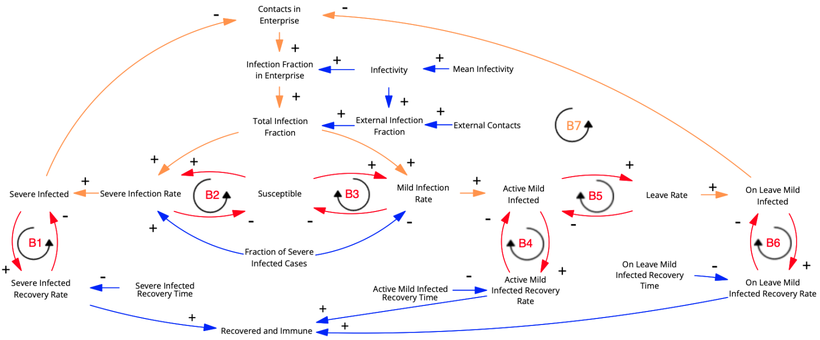

Figure: Causal loop diagram illustrating the seasonal epidemic model.

Seasonal Epidemic Model - Causal Loop Diagram

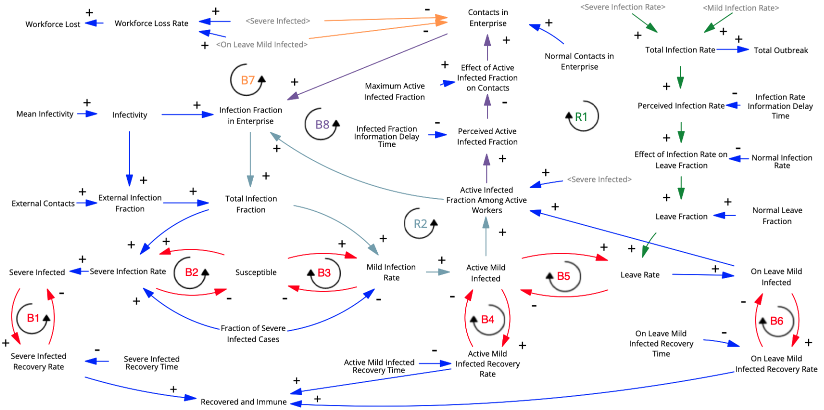

Figure: Causal loop diagram illustrating the seasonal epidemic model.

Seasonal Epidemic Model Experiments

- Epidemic scenarios for influenza are defined by varying:
  - **Mean Infectivity:** Probability that a contact between an infected and a susceptible individual results in infection. Infectivity is modelled as a sinusoidal function of time [6, 7].
  - **Fraction of Severe Infected Cases:** Fraction of susceptible individuals who become severely infected (as opposed to mildly infected) upon contracting the disease.
- **Normal Leave Fraction:** Another key parameter defining scenarios that reflect varying organizational sick-leave cultures.
- We examined how these parameters influence total workforce loss and outbreak magnitude under different workplace behaviors.

Seasonal Epidemic Model - Experimental Results

Table: Simulation results for various epidemic scenarios in the baseline seasonal epidemic model.

Parameters			Results	
Normal Leave Fraction	Mean Infectivity	Severe Infected Fraction	Workforce Lost	Outbreak
High	Low	Low	882.5	421.9
High	Low	High	1245.6	401.5
High	High	Low	1351.0	597.3
High	High	High	1870.0	573.2
Normal	Low	Low	864.8	463.0
Normal	Low	High	1272.9	438.7
Normal	High	Low	1318.2	649.2
Normal	High	High	1903.9	623.0
Low	Low	Low	780.9	526.5
Low	Low	High	1273.2	497.2
Low	High	Low	1165.4	722.1
Low	High	High	1867.5	695.1

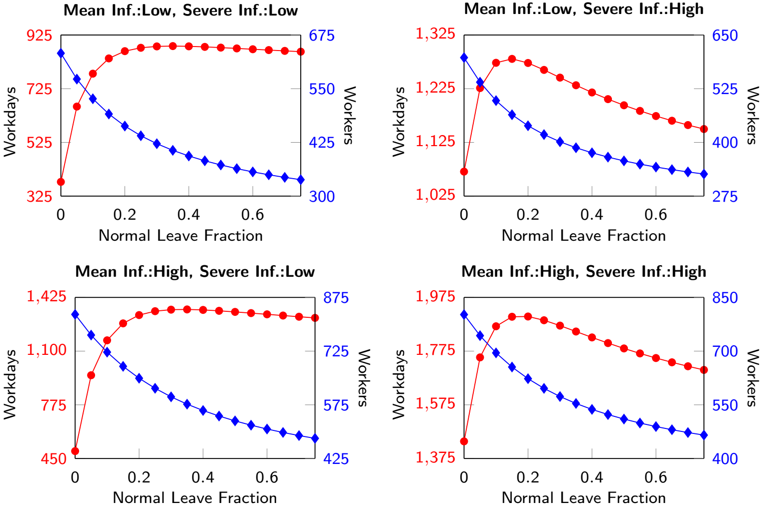

Figure: Workforce loss and outbreak size results across four epidemic scenarios, plotted against normal leave fraction values.

Workforce Loss
Total Outbreak

Policy Experiments

- **Proactive Leave Management:** Grant leave to mildly infected employees who are actively working, in addition to those already taking leave
- **Minimum Infected Fraction Threshold:**
  - Set sufficiently high to prevent unnecessary absenteeism during low infection risk periods
  - Set sufficiently low to allow for timely interventions when infection levels indicate significant transmission potential
- **Leave Granting Coefficient:**
  - Reflects the aggressiveness of leave-granting decisions

$$\text{Fraction to be Granted Leave} = \max(\text{Perceived Active Infected Fraction in Enterprise} - \text{Minimum Infected Fraction for Granting Leave}, 0) \times \text{Granting Leave Coefficient} \quad (1)$$

$$\text{Management Granting Leave Fraction} = \max(0, \min(\text{Fraction to be Granted Leave}, \text{Maximum Granting Leave Fraction}) - \text{Leave Fraction}) \quad (2)$$

Policy Experiments - Stock Flow Diagram

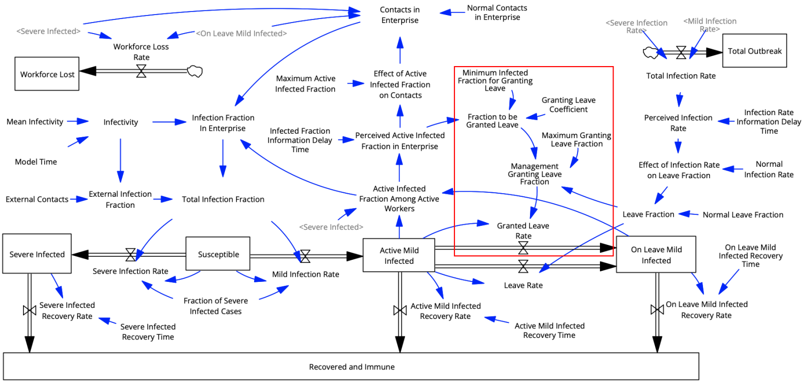

Figure: Stock flow diagram illustrating the managerial policy implementation in a seasonal epidemic model.

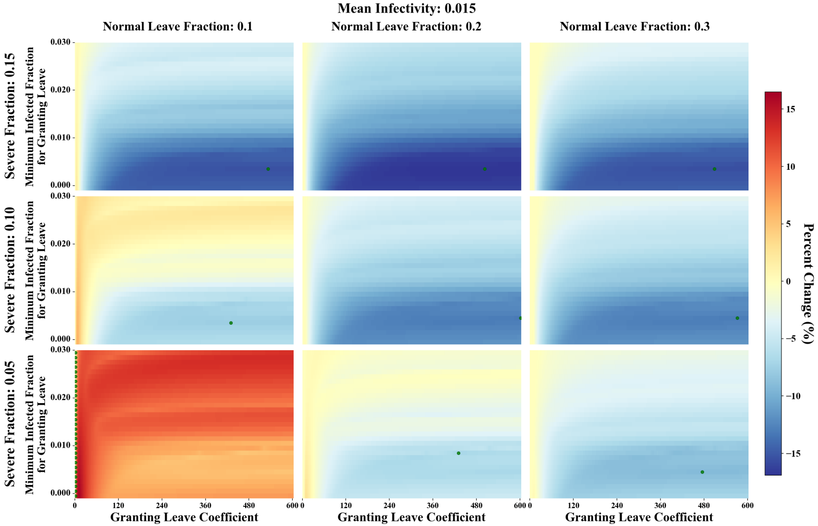

Figure: Percentage change in workforce loss under varying leave policies

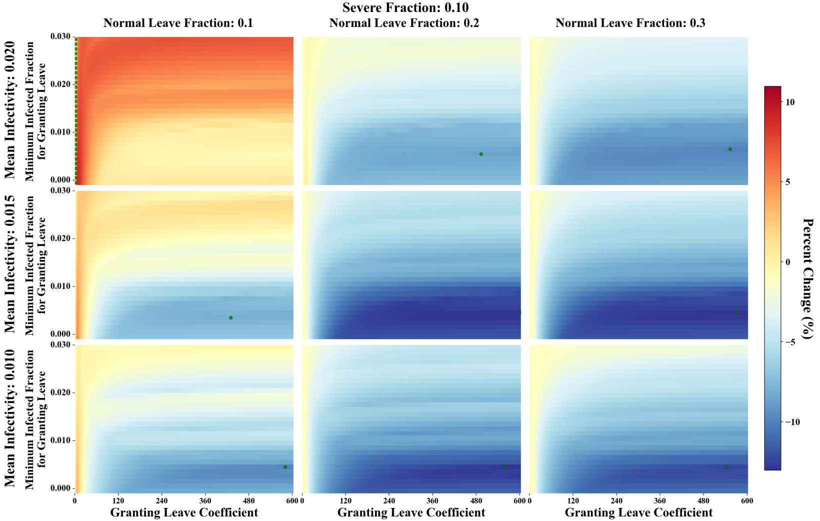

Figure: Percentage change in workforce loss under varying leave policies

Discussion and Conclusion

Effectiveness of Policies: Implementing appropriately calibrated leave-granting policies significantly mitigates workforce disruption:

- Workforce losses reduced by up to **16.9%**
- Outbreak sizes decreased by up to **34.5%**

Tailored Managerial Interventions: Effective workforce management requires policy customization based on:

- Epidemic characteristics (infectivity, severity)
- Organizational sick-leave culture (presenteeism vs. absenteeism behaviors)

Strategic Decision-Making: Dynamic modeling provides actionable insights, enabling proactive policy adjustments to maintain operational continuity and enhance organizational resilience during seasonal epidemics.

References

[1] Christina Hansen Edwards, Gianpaolo Scalia Tomba, and Birgitte Freiesleben de Blasio. "Influenza in workplaces: transmission, workers' adherence to sick leave advice and European sick leave recommendations". In: *The European Journal of Public Health* 26.3 (2016), pp. 478–485.

[2] Matthew R Groenewold. "Health-related workplace absenteeism among full-time workers–United States, 2017–18 influenza season". In: *MMWR. Morbidity and Mortality Weekly Report* 68 (2019).

[3] Marie-Hélène Blanchet Zumofen, Jeff Frimpter, and Svenn Alexander Hansen. "Impact of influenza and influenza-like illness on work productivity outcomes: a systematic literature review". In: *Pharmacoeconomics* 41.3 (2023), pp. 253–273.

[4] Abay Asfaw, Roger Rosa, and Regina Pana-Cryan. "Potential economic benefits of paid sick leave in reducing absenteeism related to the spread of influenza-like illness". In: *Journal of Occupational and Environmental Medicine* 59.9 (2017), pp. 822–829.

[5] W Bamberg et al. "Outbreaks of 2009 Pandemic Influenza A (H1N1) Among Long-Term-Care Facility Residents–Three States, 2009.". In: *JAMA: Journal of the American Medical Association* 303.12 (2010).

[6] Nicholas C Grassly and Christophe Fraser. "Seasonal infectious disease epidemiology". In: *Proceedings of the Royal Society B: Biological Sciences* 273.1600 (2006), pp. 2541–2550.

[7] Sonia Altizer et al. "Seasonality and the dynamics of infectious diseases". In: *Ecology letters* 9.4 (2006), pp. 467–484.

Thank you for your attention

ahmet.sener@std.bogazici.edu.tr
senerahmetemir@gmail.com