Clinician Burnout from a Markov Perspective

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Healthcare Systems Engineering Institute
Northeastern University

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About Us

Our Mission
Broad regional and national impact on healthcare improvement through education, research, and application in systems engineering methods.

Research Portfolios
- Opioids
- Safety
- Access
- Methods
- Burden
- Diagnostic

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Defining Burnout

1. Emotional exhaustion (EE) - Lost energy; feeling of exhaustion and depletion of emotional energy.
2. Depersonalization (DP) - Lost enthusiasm; feeling distant, not passionate and having impersonal relationships with recipients of care and colleagues.
3. Personal accomplishment (PA) - Lost confidence; feeling incompetent and having no active involvement in work.

- “Physical or mental collapse caused by overwork or stress” (Herbert Freudenberger - 1970)
- “A general experience of physical, emotional and attitudinal exhaustion” (Pines and Kafry, 1978)
- “Negative personal changes which occur over time in helping professionals working demanding or frustrating jobs.” (Cherniss 1980)

Relate burnout to human service professions, with interpersonal stress as its cause (Maslach & Jackson, 1981); that is, emotional burnout is related to feelings experienced by people whose jobs require repeated exposure to emotionally charged interpersonal situations.

- “A syndrome of emotional exhaustion, depersonalization and reduced accomplishment that can occur among individuals.” (Maslach 1982)

Burned out if:

- EE: Low <=18, Med 19-26, High >=27
- DP: Low <=5, Med 6-9, High >=10
- PA: Low >=40, Med 34-39, High <33
Why Clinician Burnout?

1. **Compromised patient safety**
   - Burnout is associated with poor patient safety outcomes such as medical errors\textsuperscript{6}.
   - Errors in patient care in national health services healthcare settings make up to approximately **$3.3B annually** in extra care provision and litigation payouts\textsuperscript{7}.

2. **Turnover and its associated costs**
   - Burnout drives intent to leave\textsuperscript{8}.
   - Costs of replacing a doctor who leaves their job are estimated at **$4.6B annually**\textsuperscript{9}.

3. **Because acting on it makes a difference**\textsuperscript{8}
   - Actions to decrease burnout are effective
Clinician Burnout Statistics

Clinic Burnout Statistics

How has Burnout been explored?

- Measurement – MBI Gold standard
- Statistical analysis and prediction
- System Dynamics models – understanding context
- Progression Model – defining phases of burnout
- Markov Chains (MC) – to understand transitions and times associated with transitions
- Markov Decision Processes (MDP) – to understand the effect of different interventions
Aims

Leveraging what has been explored, mainly measurement aspect (MBI results) and Progression of Burnout model (8-Phase), to solve the inverse problem and find the expected transitions and transition times related to burnout.

I. When to intervene (MC)

II. Prioritize with whom to intervene (MC)

III. Evaluate different interventions using (MDP)
# Markov Chains

A stochastic model describing a sequence of possible events in which the probability of each event depends only on the state attained in the previous event.

<table>
<thead>
<tr>
<th>Time</th>
<th>State space</th>
<th>Markov Decision Process (MDP)</th>
<th>Partially Observable Markov Decision Process (POMDP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discrete</td>
<td>The sequence (A, B, C or T) at each base (1, 2, 3, 4, 5, 6, 7, 8, 9, 10)</td>
<td>Intensity of sun measured everyday</td>
<td>Brain activity (magnetic field) continuously monitored</td>
</tr>
<tr>
<td>Continuous</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>Hidden Markov Model (HMM)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Approach

Administer MBI at different time points

Create direction and movement matrix

Translate to n-step transition probability matrix

Solve inverse optimization problem to find the transition matrix

Calculate Markov performance measures

2) Mean time until a person first transitions from burnout phase \( i \) to phase \( j \) – \( m_{ij} \),

3) Mean time until a person returns back to same burnout phase – \( \mu_{ij} \).
Inverse MC Model

• Objective: Find a transition matrix that minimizes the difference between the 12-step transition matrixes (collected data and calculated data).

<table>
<thead>
<tr>
<th>Transition matrix</th>
<th>P(12) Collected</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>P</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0.2063</td>
</tr>
<tr>
<td>2</td>
<td>0.1259</td>
</tr>
<tr>
<td>3</td>
<td>0.0461</td>
</tr>
<tr>
<td>4</td>
<td>0.0459</td>
</tr>
<tr>
<td>5</td>
<td>0.0476</td>
</tr>
<tr>
<td>6</td>
<td>0.0457</td>
</tr>
<tr>
<td>7</td>
<td>0.1197</td>
</tr>
<tr>
<td>8</td>
<td>0.1173</td>
</tr>
</tbody>
</table>

P(12) Calculated

• Constraints: The model is constrained by having higher probabilities for adjacent transitions compared to further ones and that probability of staying in the same state is larger than transitioning to further states.
## MC Equations

<table>
<thead>
<tr>
<th>Name</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapman Kolmogrov assuming 8-phase model</td>
<td>$P(t) = P^t$</td>
</tr>
<tr>
<td>N-Step transition probability matrix</td>
<td>$P(t) = P^t = \begin{bmatrix} p_{11}^t &amp; \cdots &amp; p_{18}^t \ \vdots &amp; \ddots &amp; \vdots \ p_{81}^t &amp; \cdots &amp; p_{88}^t \end{bmatrix}$</td>
</tr>
<tr>
<td>Steady state probability</td>
<td>$\pi_i = \sum_{j=1}^{8} \pi_j P_{ij}$, $\sum \pi_j = 1$</td>
</tr>
<tr>
<td>Mean First Passage Time from phase 1 to phase 2</td>
<td>$m_{12} = \frac{1}{1 - p_{11}} + \frac{p_{13}}{1 - p_{11}} \left( \frac{1 - p_{11} + p_{31}}{(1 - p_{33})(1 - p_{11}) - p_{11}p_{31}} \right)$</td>
</tr>
<tr>
<td>Mean Recurrence Time</td>
<td>$\mu_j = \frac{1}{\pi_j}$</td>
</tr>
</tbody>
</table>
### Performance Measures

#### Mean First Passage Time Matrix

<table>
<thead>
<tr>
<th>P</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>15.124</td>
<td>15.150</td>
<td>15.523</td>
<td>12.331</td>
<td>10.617</td>
<td>5.489</td>
<td>9.120</td>
<td>6.650</td>
</tr>
</tbody>
</table>

#### Steady State Probability

<table>
<thead>
<tr>
<th>P</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.089</td>
<td>0.106</td>
<td>0.144</td>
<td>0.145</td>
<td>0.123</td>
<td>0.121</td>
<td>0.174</td>
<td>0.100</td>
</tr>
</tbody>
</table>
Interesting Finding!

### Teachers

<table>
<thead>
<tr>
<th>P(192)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.30</td>
<td>0.07</td>
<td>0.09</td>
<td>0.07</td>
<td>0.11</td>
<td>0.12</td>
<td>0.05</td>
<td>0.19</td>
</tr>
<tr>
<td>2</td>
<td>0.30</td>
<td>0.07</td>
<td>0.09</td>
<td>0.07</td>
<td>0.11</td>
<td>0.12</td>
<td>0.05</td>
<td>0.19</td>
</tr>
<tr>
<td>3</td>
<td>0.30</td>
<td>0.07</td>
<td>0.09</td>
<td>0.07</td>
<td>0.11</td>
<td>0.12</td>
<td>0.05</td>
<td>0.19</td>
</tr>
<tr>
<td>4</td>
<td>0.30</td>
<td>0.07</td>
<td>0.09</td>
<td>0.07</td>
<td>0.11</td>
<td>0.12</td>
<td>0.05</td>
<td>0.19</td>
</tr>
<tr>
<td>5</td>
<td>0.30</td>
<td>0.07</td>
<td>0.09</td>
<td>0.07</td>
<td>0.11</td>
<td>0.12</td>
<td>0.05</td>
<td>0.19</td>
</tr>
<tr>
<td>6</td>
<td>0.30</td>
<td>0.07</td>
<td>0.09</td>
<td>0.07</td>
<td>0.11</td>
<td>0.12</td>
<td>0.05</td>
<td>0.19</td>
</tr>
<tr>
<td>7</td>
<td>0.30</td>
<td>0.07</td>
<td>0.09</td>
<td>0.07</td>
<td>0.11</td>
<td>0.12</td>
<td>0.05</td>
<td>0.19</td>
</tr>
<tr>
<td>8</td>
<td>0.30</td>
<td>0.07</td>
<td>0.09</td>
<td>0.07</td>
<td>0.11</td>
<td>0.12</td>
<td>0.05</td>
<td>0.19</td>
</tr>
</tbody>
</table>

**Steady State Calculated**

- **Teachers**
  - 0.46
  - 0.18
  - 0.36

### Police

#### Burnout Phases in Three Police Populations

1. **U.S. State Police (91)**
- Low: 31.9%
- Medium: 13.2%
- High: 31.9%

2. **Canadian Urban Police Academy (708)**
- Low: 23.3%
- Medium: 7.1%
- High: 44.9%

3. **Canadian Urban Police Academy (424)**
- Low: 18.4%
- Medium: 7.5%
- High: 42.2%

### Nurses

#### Table 3. Prevalence of burnout according to the stages of the Golembiewski model.

<table>
<thead>
<tr>
<th>Phase</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>D</td>
<td>L</td>
<td>H</td>
<td>L</td>
<td>H</td>
<td>L</td>
<td>H</td>
<td>L</td>
<td>H</td>
</tr>
<tr>
<td>PA</td>
<td>L</td>
<td>L</td>
<td>H</td>
<td>H</td>
<td>L</td>
<td>L</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>n</td>
<td>39</td>
<td>14</td>
<td>57</td>
<td>26</td>
<td>29</td>
<td>59</td>
<td>35</td>
<td>15</td>
</tr>
<tr>
<td>(%)</td>
<td>(14.2)</td>
<td>(5.1)</td>
<td>(27.9)</td>
<td>(10.4)</td>
<td>(19.5)</td>
<td>(38.1)</td>
<td>(2.8)</td>
<td>(5.5)</td>
</tr>
</tbody>
</table>

**Steady State Probability. At any point in time in any population, people may be distributed across the burnout phases in a similar way. Average distribution of burnout (low, medium and high) is (0.4483, 0.1336, 0.4176)**
Summary

• Work backwards to find a general transition matrix with transition probabilities
• Estimate transitions over time
• Find times at each state before transitioning
• Insight on more effective interventions
References

1. Maslach C. What we have learned about burnout and health. Psychol Health 2001; 16: 607–11. 5. Maslach C and Leiter M.


7. Department of health, 2000


Questions

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