Northeastern

Clinician Burnout from a Markov Perspective

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About Us

Northeastern University
Healthcare Systems Engineering Institute

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

Burned out if:

"Physical or mental collapse caused by overwork or stress" (Herbert Freudenberger - 1970)

of

"A general experience of physical, emotional and attitudinal exhaustion" (Pines and Kafry, 1978)

(2) "Negative personal changes which occur over time in helping professionals working demanding or frustrating jobs." (Cherniss 198

coll

Relate burnout to human service professions, with interpersona 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 interpersona situat

(3) Per

feeling ir

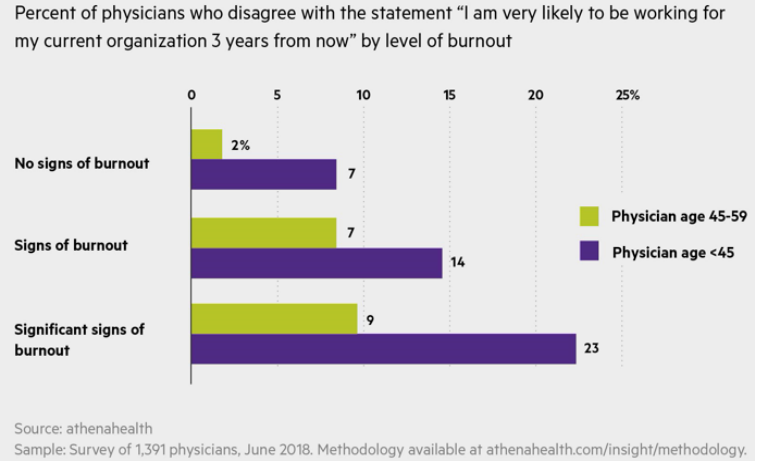
in work[1,2]

"A syndrome of emotional exhaustion, depersonalization reduced accomplishment that can occur among individuals." (Maslach 1982)

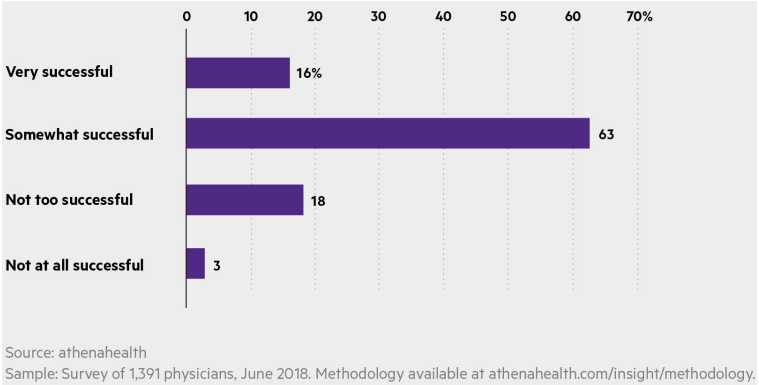
[3-5]	EE	DP	PA
Low	<=18	<=5	>=40
Med	19-26	6-9	34-39
High	>=27	>=10	<=33

Why Clinician Burnout?

1. **Compromised patient safety**
   - Burnout is associated with poor patient safety outcomes such as medical errors[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[7].

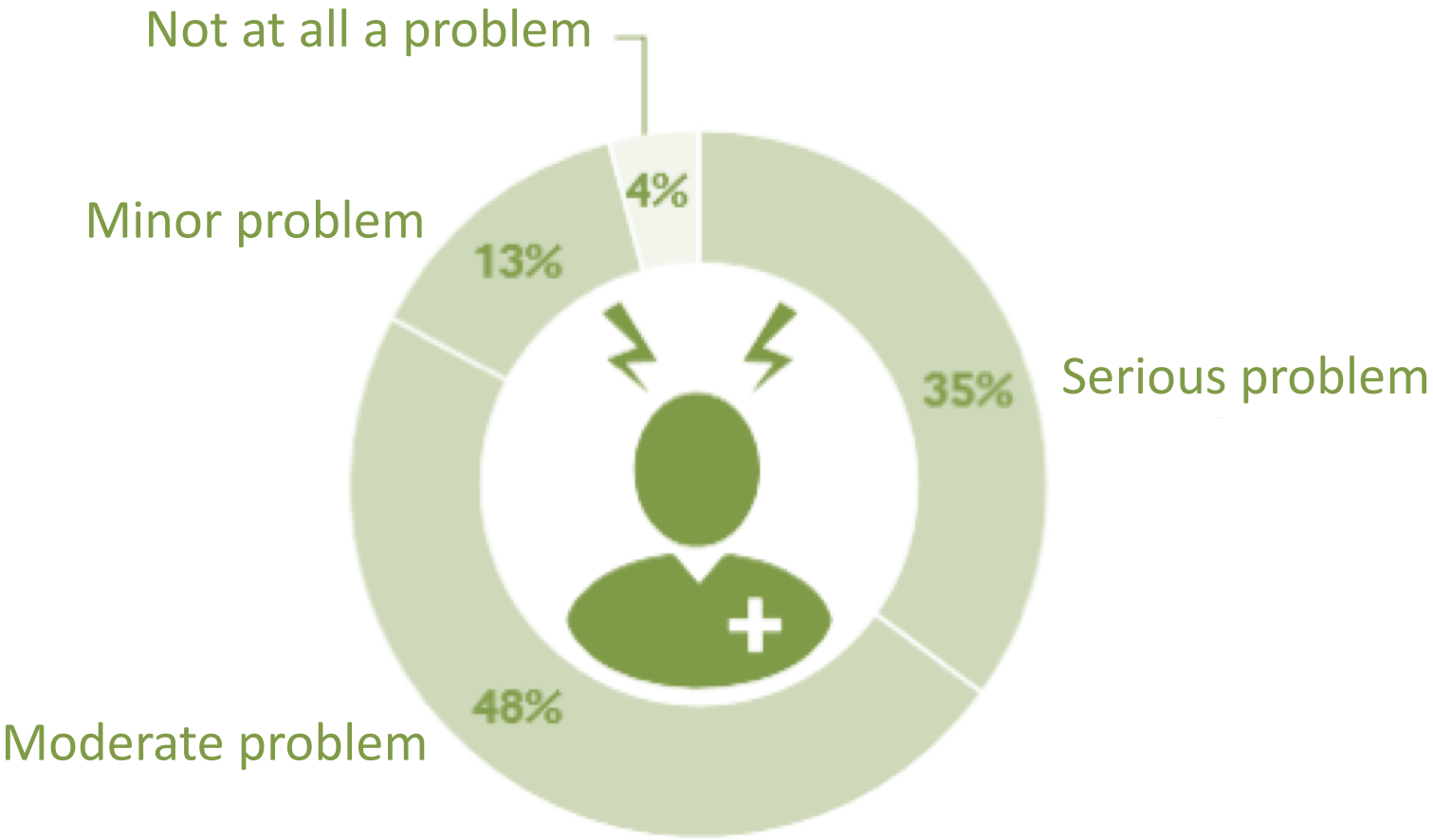


2. **Turnover and its associated costs**
   - Burnout drives intent to leave[8].
   - Costs of replacing a doctor who leaves their job are estimated at **$4.6B annually**[9].



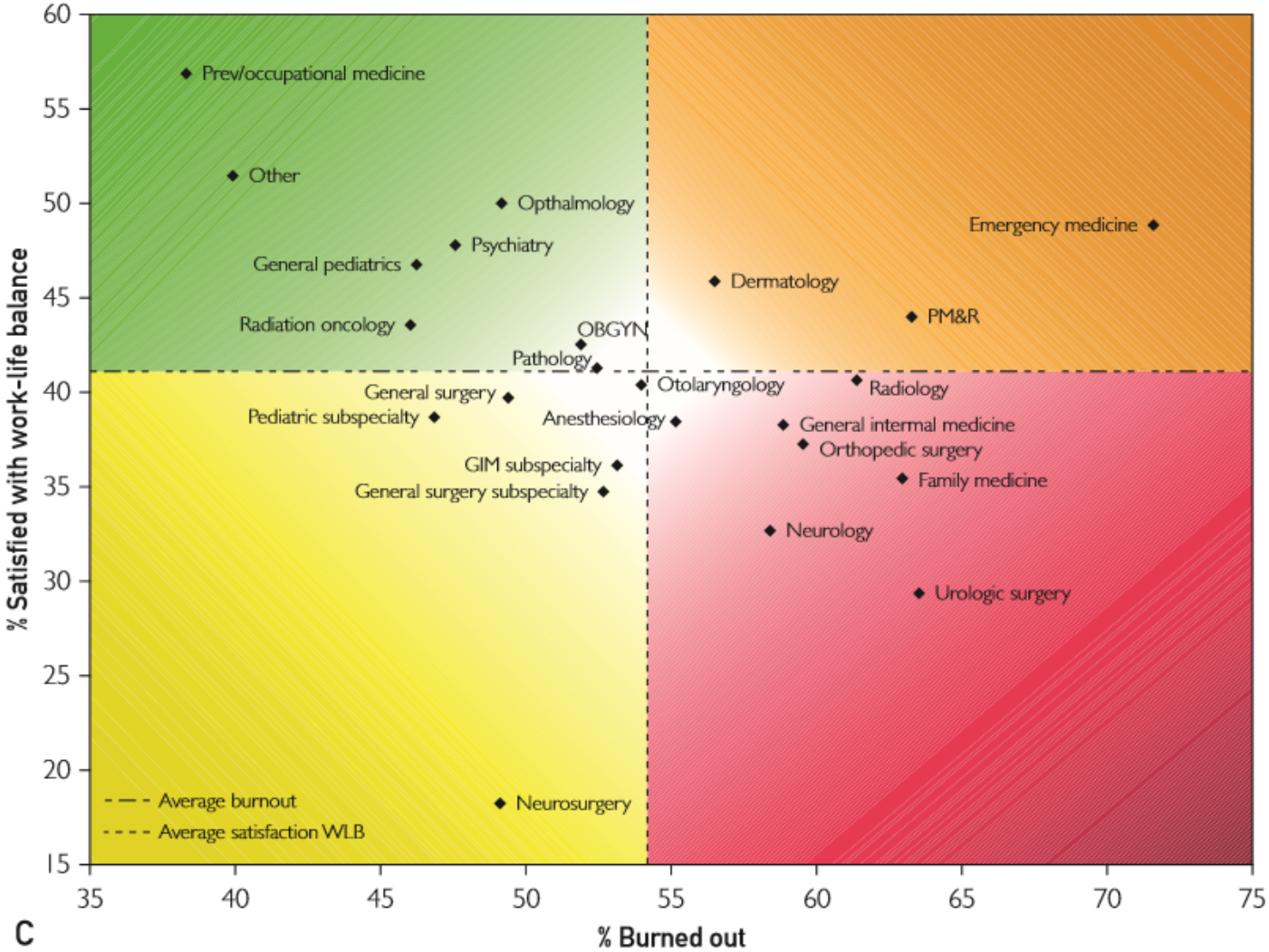
3. **Because acting on it makes a difference**[8]
   - Actions to decrease burnout are effective

Clinician Burnout Statistics



Source:[10] Swensen, Strongwater, Mohta. (2018). Leadership Survey: Immunization Against Burnout. Insight report

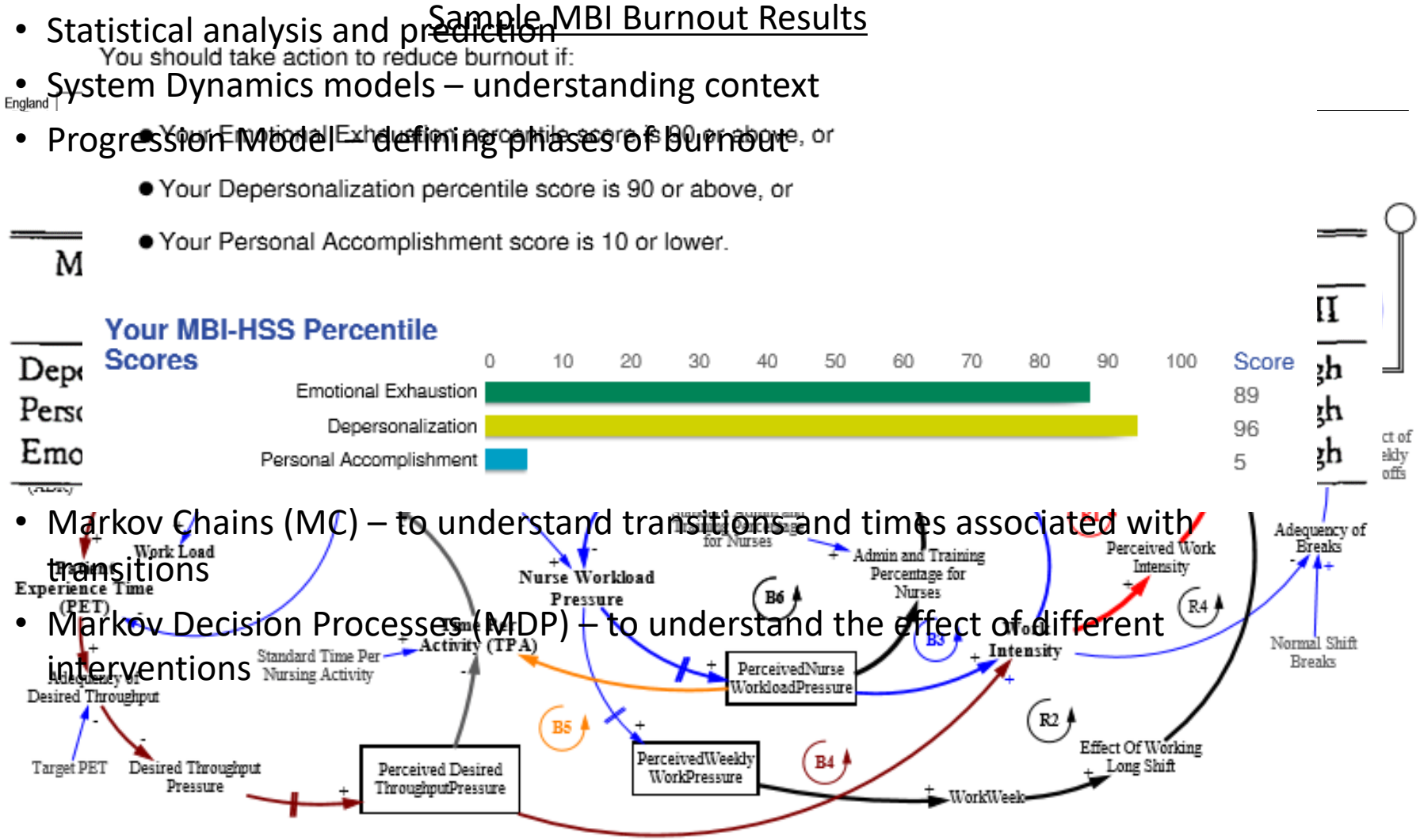
Clinician Burnout Statistics



Source[11]: Shanafelt, Hasan, Dyrbye, Sinsky, Satele, Sloan, & West. (2015). Changes in Burnout and Satisfaction With Work-Life Balance in Physicians and the General US Working Population Between 2011 and 2014. Mayo Clinic Proceedings, 90(12), 1600-1613.

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.

		State space			
		Discrete		Continuous	
Time	Discrete	The sequence (A, B, C or T) at each base (1, 2, 3, 4, 5, 6, 7, 8, 9, 10)		Yes Intensity of sun measured everyday	
				Markov Decision Process (**MDP**)	
	Continuous				
		y Whether there is a heartbeat or e not over surgery time	No	Hidden Markov Model (**HMM**)	Branch Partially observable Markov field) continuously monitored Decision Process (**POMDP**)
				(**MC**)	

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

Direction and movement

P	1	2	3	4	5	6	7	8	Total
1	46	5	4	1	6	2	4	1	69.000
2	5	7	0	0	2	4	0	3	21.000
3	10	1	12	7	0	0	2	4	36.000
4	5	3	4	9	1	1	1	6	30.000
5	8	1	3	1	6	5	0	3	27.000

INPUTS

Choose a model

Number of states

8 States model

Choose a method to calculate the transition matrix

Starting point

Power

Choose an objective function

Objective function

Sum of absolute differences

P(12) Data

P	1	2	3	4	5	6	7	8
1	0.667	0.072	0.058	0.014	0.087	0.029	0.058	0.014
2	0.238	0.333	0.000	0.000	0.095	0.190	0.000	0.143
3	0.278	0.028	0.333	0.194	0.000	0.000	0.056	0.111
4	0.167	0.100	0.133	0.300	0.033	0.033	0.033	0.200
5	0.296	0.037	0.111	0.037	0.222	0.185	0.000	0.111
6	0.054	0.054	0.027	0.000	0.189	0.405	0.027	0.243
7	0.059	0.000	0.176	0.000	0.294	0.059	0.118	0.294
8	0.043	0.029	0.043	0.114	0.043	0.143	0.086	0.500

OUTPUTS

Objective Function Value

4.82

Transition Matrix

P	1	2	3	4	5	6	7	8
1	0.667	0.072	0.058	0.014	0.087	0.029	0.058	0.014
2	0.238	0.333	0.000	0.000	0.095	0.190	0.000	0.143
3	0.278	0.028	0.333	0.194	0.000	0.000	0.056	0.111
4	0.167	0.100	0.133	0.300	0.033	0.033	0.033	0.200
5	0.296	0.037	0.111	0.037	0.222	0.185	0.000	0.111
6	0.054	0.054	0.027	0.000	0.189	0.405	0.027	0.243
7	0.059	0.000	0.176	0.000	0.294	0.059	0.118	0.294
8	0.043	0.029	0.043	0.114	0.043	0.143	0.086	0.500

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).

Transition matrix

P	1	2	3	4	5	6	7	8
1	0.2063	0.4632	0.0530	0.0516	0.0497	0.0499	0.0538	0.0727
2	0.1259	0.1259	0.4888	0.0336	0.0327	0.0327	0.0346	0.1259
3	0.0461	0.1259	0.0648	0.5552	0.0466	0.0465	0.0501	0.0648
4	0.0459	0.0530	0.3520	0.1096	0.2607	0.0466	0.0501	0.0821
5	0.0476	0.0542	0.0498	0.1101	0.2045	0.3725	0.0511	0.1101
6	0.0457	0.0517	0.0472	0.0462	0.1278	0.1397	0.4516	0.0900
7	0.1197	0.0008	0.0564	0.0619	0.1025	0.1390	0.3939	0.1259
8	0.1173	0.1259	0.0553	0.1096	0.1196	0.1259	0.2205	0.1259

P(12) Collected

P	1	2	3	4	5	6	7	8
1	0.6667	0.0725	0.0580	0.0145	0.0870	0.0290	0.0580	0.0145
2	0.2381	0.3333	0.0000	0.0000	0.0952	0.1905	0.0000	0.1429
3	0.2778	0.0278	0.3333	0.1944	0.0000	0.0000	0.0556	0.1111
4	0.1667	0.1000	0.1333	0.3000	0.0333	0.0333	0.0333	0.2000
5	0.2963	0.0370	0.1111	0.0370	0.2222	0.1852	0.0000	0.1111
6	0.0541	0.0541	0.0270	0.0000	0.1892	0.4054	0.0270	0.2432
7	0.0588	0.0000	0.1765	0.0000	0.2941	0.0588	0.1176	0.2941
8	0.0429	0.0286	0.0429	0.1143	0.0429	0.1429	0.0857	0.5000

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

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

Performance Measures

Mean First Passage Time Matrix

P	1	2	3	4	5	6	7	8
1	11.042	12.855	14.421	12.424	11.319	9.091	9.662	7.331
2	11.010	11.953	11.330	12.236	13.586	12.171	11.727	8.172
3	14.622	14.996	3.049	11.278	15.079	14.976	14.244	13.410
4	15.267	15.345	15.323	11.512	2.671	6.023	11.342	8.643
5	14.985	15.135	15.569	11.557	8.851	4.261	10.280	7.706
6	15.124	15.150	15.523	12.331	10.617	5.489	9.120	6.650
7	15.524	15.362	15.392	12.635	11.686	9.435	9.002	4.168
8	16.440	15.328	14.858	12.759	13.429	11.502	9.004	2.848

Steady State Probability

1	2	3	4	5	6	7	8
0.089	0.106	0.144	0.145	0.123	0.121	0.174	0.100

Interesting Finding!

Teachers

P(192)	1	2	3	4	5	6	7	8
1	0.30	0.07	0.09	0.07	0.11	0.12	0.05	0.19
2	0.30	0.07	0.09	0.07	0.11	0.12	0.05	0.19
3	0.30	0.07	0.09	0.07	0.11	0.12	0.05	0.19
4	0.30	0.07	0.09	0.07	0.11	0.12	0.05	0.19
5	0.30	0.07	0.09	0.07	0.11	0.12	0.05	0.19
6	0.30	0.07	0.09	0.07	0.11	0.12	0.05	0.19
7	0.30	0.07	0.09	0.07	0.11	0.12	0.05	0.19
8	0.30	0.07	0.09	0.07	0.11	0.12	0.05	0.19

Steady State Calculated

0.46	**0.18**	**0.36**

Police

Burnout Phases in Three Police Populations

	1	2	3	4	5	6	7	8
1. U.S. State Police (91)	31.9	13.2	6.6	8.8	1.1	16.5	2.2	19.8
		51.6					38.2	
2. Canadian Urban Police Academy (708)	23.3	7.1	14.5	4.9	7.3	11.9	9.9	23.0
		44.9					42.8	
3. Canadian Urban Police Academy (424)	18.4	7.5	16.3	4.0	7.3	9.0	5.7	31.8
		42.2					46.5	

Nurses[12]

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

Phase	1	2	3	4	5	6	7	8
EE	L	L	L	L	H	H	H	H
D	L	H	L	H	L	H	L	H
PA	L	L	H	H	L	L	H	H
n	39	14	57	26	29	59	35	15
(%)	(14.2)	(5.1)	(20.8)	(9.5)	(10.6)	(21.5)	(12.8)	(5.5)

40.1 **20.1** **39.8**

H = High; L = Low; EE = Emotional exhaustion; D = Depersonalisation; PA = Personal accomplishment

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

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Questions

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