

Mental Health at the Claremont Colleges: A Markov Chain Process

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MATH183: Mathematical Modeling

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Overview

- 1 Introduction/Literature Review
- 2 Sample Statistics
- 3 Mathematical Background
- 4 Heterogeneity
 - Demographics
 - External
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Content Warning

The following presentation contains references to mental ill-health, depression, and suicide.

Introduction

- Global trend of decline in mental health, partially due to increased facilities for diagnosis.
- 1 in 4 individuals suffer from depression at some point in their lives.
- Statistics still understate scale of mental health problem, 36% of Indian population suffering from some major form of depression. Suicide leading cause of death for Indian and Chinese women between the ages of 15 and 19.

Introduction

- Studies indicate mental illness linked to greater unemployment and lower economic welfare on average. Evidence suggests there exists a cyclical relationship between poverty and stress.
- Inhibits ability of individuals to make the most of opportunities and available facilities.
- Especially relevant on college campuses, with students being the future workforce.

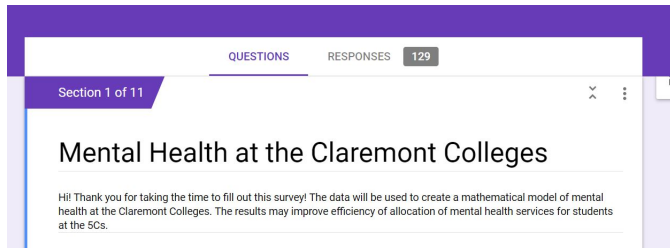
Research Question

Given the limited counseling facilities available at the Claremont Colleges, which segment of the student body needs the most attention?

Literature Review

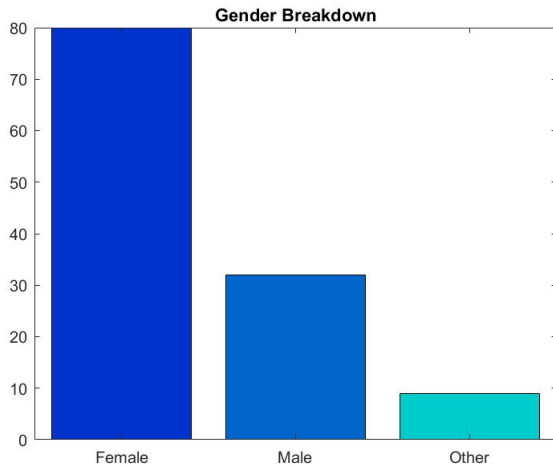
- Dunn and Skuse (1981): 2-state model, 1 year time step, t_k dependent on up to t_{k-5} .
 - A Markov model can be used, although with some limitations.
- Fischer and Knesper (1983): 4-state model, 1 day time step, dependence only on t_{k-1} .
 - Our assumptions should be acceptable.

Sample Statistics

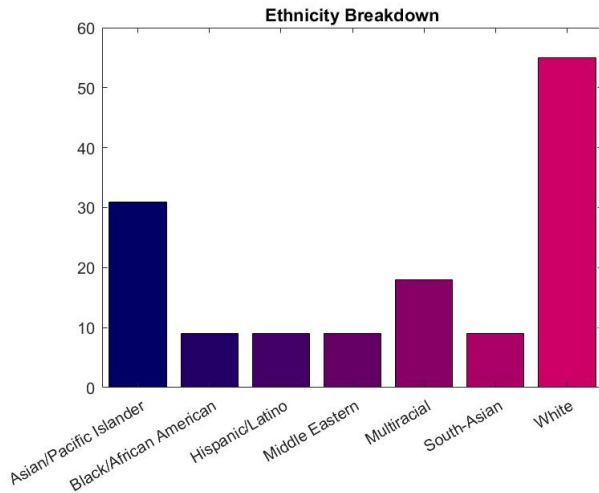


- Deleted entries: non-continuous enrollment
- 117 total entries
- Very low representation of juniors/seniors

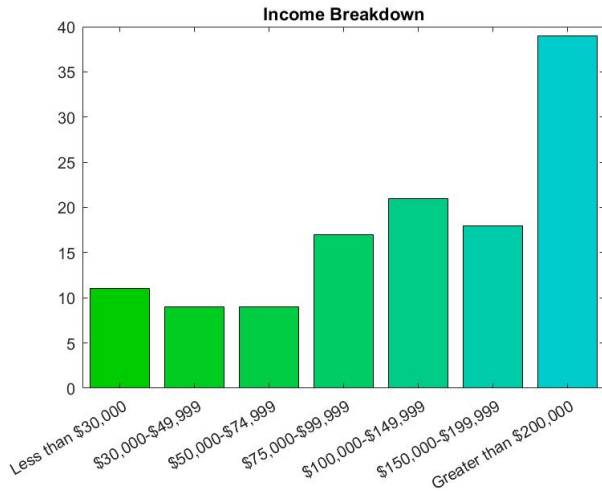
Gender



Ethnicity



Income



Rating Mental Health

- 1: Mentally unhealthy
- 2: Slightly mentally unhealthy
- 3: Slightly mentally healthy
- 4: Mentally healthy

Gathering Data

...

How would you rate your mental health on a scale of 1-4 (1 being mentally unhealthy and 4 being mentally healthy) in these periods of time? (We know that mental health is much more than a simple scale, but please do the best that you can to make a rough estimate)

	1	2	3	4	I did not attend c...
1st Half of 1st Se...	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2nd Half of 1st Se...	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1st Half of 2nd Se...	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2nd Half of 2nd S...	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Including Factors

Please check the corresponding boxes to allow us to have a more qualitative picture of what your time was like. (Therapy? – Did you seek therapy, or the help of other mental health resources during this time?; Relationship? – Were you in a romantic relationship that lasted for the majority of this time?; Abroad? – Were you studying abroad during this time?; Heavy load? – Were you enrolled in 4.5 or more credits worth of classes during this time?; Light load? – 3.5 or less?; Student-athlete? – Were you a student-athlete during this time?)

	Therapy?	Relationship?	Abroad?	Heavy Load?	Light Load?	Student-athlet...
1st Half of 1st ...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2nd Half of 1st...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1st Half of 2nd...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2nd Half of 2n...	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Markov Chain Model

The questions of interest then become: How do we model the progression of mental health? How does it differ by demographics?

- Opt to use Markov Chain models
- The main assumption is that the underlying process satisfies the following property:

$$\begin{aligned} Pr(X_{n+1} = i + 1 \mid X_n = i, X_{n-1} = i_{n-1} \cdots X_0 = i_0) \\ = Pr(X_{n+1} = i + 1 \mid X_n = i) \end{aligned}$$

- Literature suggests this is satisfied when looking at shorter time periods.

Markov Chain Model

$$\begin{array}{c} 1 \quad 2 \quad 3 \quad 4 \\ \begin{pmatrix} p_{1,1} & p_{1,2} & p_{1,3} & p_{1,4} \\ p_{2,1} & p_{2,2} & p_{2,3} & p_{2,4} \\ p_{3,1} & p_{3,2} & p_{3,3} & p_{3,4} \\ p_{4,1} & p_{4,2} & p_{4,3} & p_{4,4} \end{pmatrix} \end{array}$$

- $p_{i,j}$ is the transition probability from state i to state j satisfying the following properties:
- $0 \leq p_{i,j} \leq 1$, as they are all probabilities;
- $\sum_j p_{i,j} = 1$, that is, the rows sum up to 1.

Stationary Distribution

- Looking at transition probabilities is useful, can lead to important insights.
- May be more useful to analyze the stationary distribution corresponding to different transition matrices to analyze impact of demographics / other factors.
- Stationary distributions tell us about the proportion of the population that would be in each mental health state in the long run, given a transition matrix.

$$\pi = P\pi$$

- It is the eigenvector of the transition probability matrix corresponding to eigenvalue 1.

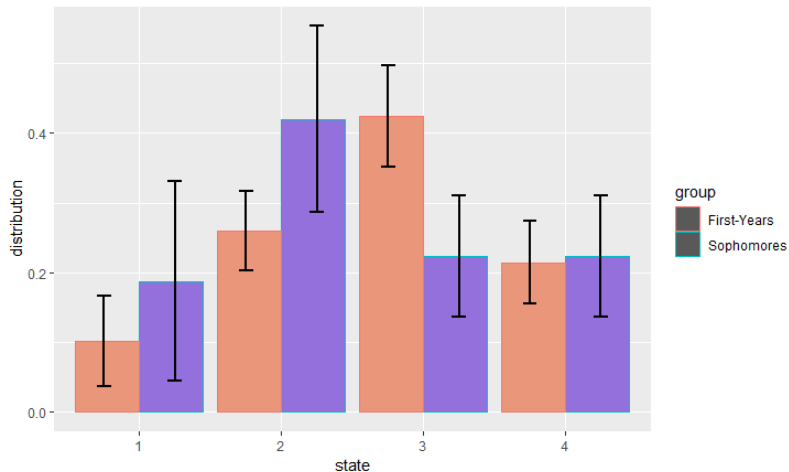
Bootstrapping

- Would like to make quantitative statements about whether stationary distributions are different (calculate confidence intervals).
- To do so, need the standard deviation of the estimate observed. May not be reliable given small sample size. Use process known as bootstrapping.

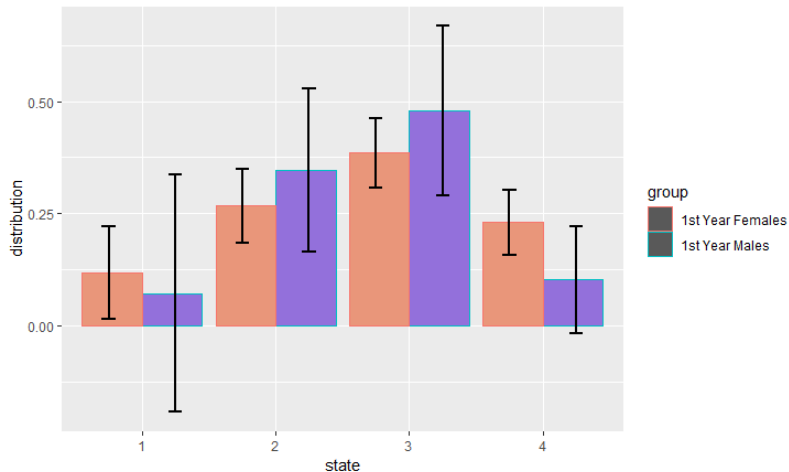
Bootstrapping

- **Example:** Imagine we have a bag with 100 balls of which 70 are red and we are interested in finding the proportion of balls that are red.
- How does would this number change if we were to resample the 100 balls we have? Difficult if resampling not possible.
- Instead, draw 70 balls from bag of 100, find proportion of balls that are red, replace, and repeat n times.
- Allows us to calculate standard errors and confidence intervals for estimates.

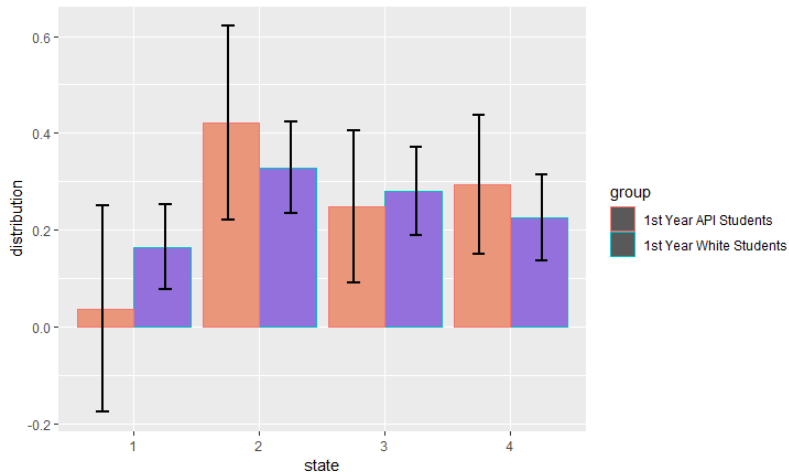
Demographic Results: Year



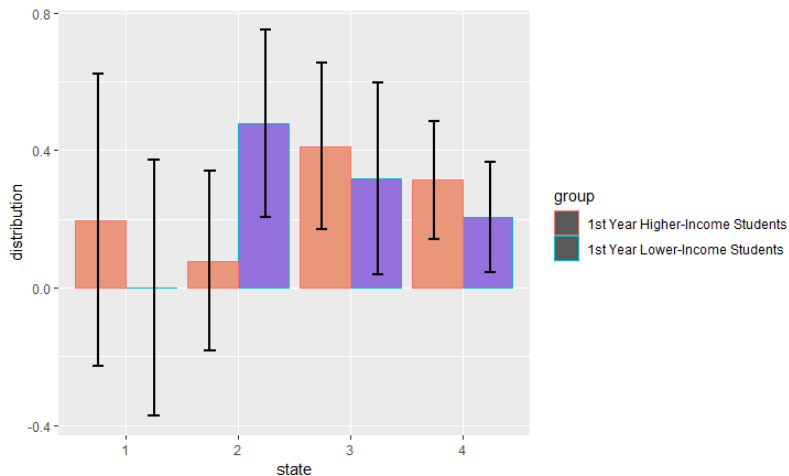
Demographic Results: Gender



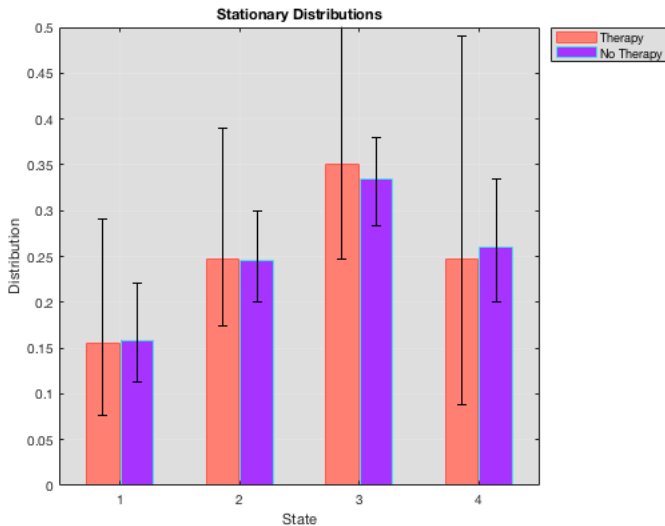
Demographic Results: Ethnicity



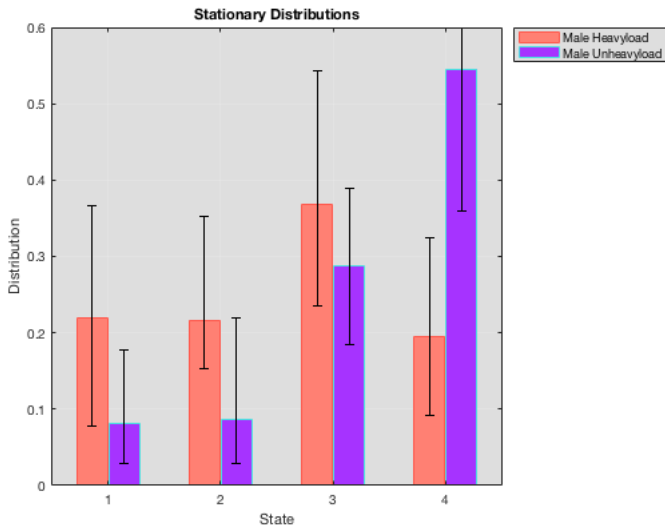
Demographic Results: Income



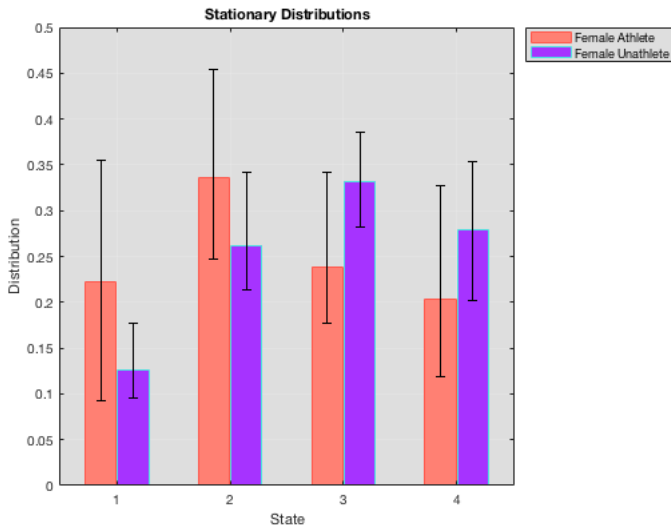
External Factor Results: Therapy



External Factor Results: Heavy Course Load \times Gender



External Factor Results: Student-Athlete \times Gender



Conclusion

- Create stronger support networks for sophomores and directing counseling services toward students starting at the beginning of their 3rd semester
- Build upon support systems and specialized counseling services for low-income students
- Increase support for female-identifying student-athletes, and improved accountability measures for women's athletics
- Most importantly, conduct further research to identify 'at risk' groups

Suggestions for Future Research

- Increase the sample size and diversity of students who answer the survey
- Generate more accurate stationary distributions with tighter confidence intervals for a wider variety of filters

Suggestions for Future Research

- Be more specific with the 1-4 scale, to increase accurate self-reporting. Perhaps:
 - 1: Severely Mentally Unhealthy
 - 2: Mentally Unhealthy
 - 3: Some Mental Health Problems
 - 4: Mentally Healthy
- Collect data for summer break as well