Dr. Strangetooth or: How I learned to stop worrying and love the PROC

A Thesis Defense By Emma Kaz Frick

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UMKC SOM

Biomedical and Health Informatics

https://www.ifccenter.com/films/dr-strangelove/

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Nontraumatic Dental Conditions in U.S. Emergency Departments

Narrowing My Research Question

Interest in the current state of the medical-dental divide

- How is our healthcare delivery system currently functioning?
- What problems are created by separation of professional disciplines like medicine and dentistry?
- Who is falling though the cracks in the system and going without care?

System Weakness: Dental emergencies

- For those who do not have a dentist or can't get in soon enough, what happens?
- Who is most vulnerable and what are the key risk factors to identify them?

Apply my new knowledge and investigative toolkit to this issue:

Investigate the key characteristics associated with emergency encounters for preventable dental conditions

Research Hypothesis

Based on what I knew from the literature…

*Certain **patient characteristics** recorded within the encounter record broadly related to social or economic determinants **will modify** the **odds** of visiting the ED for preventable dental conditions*

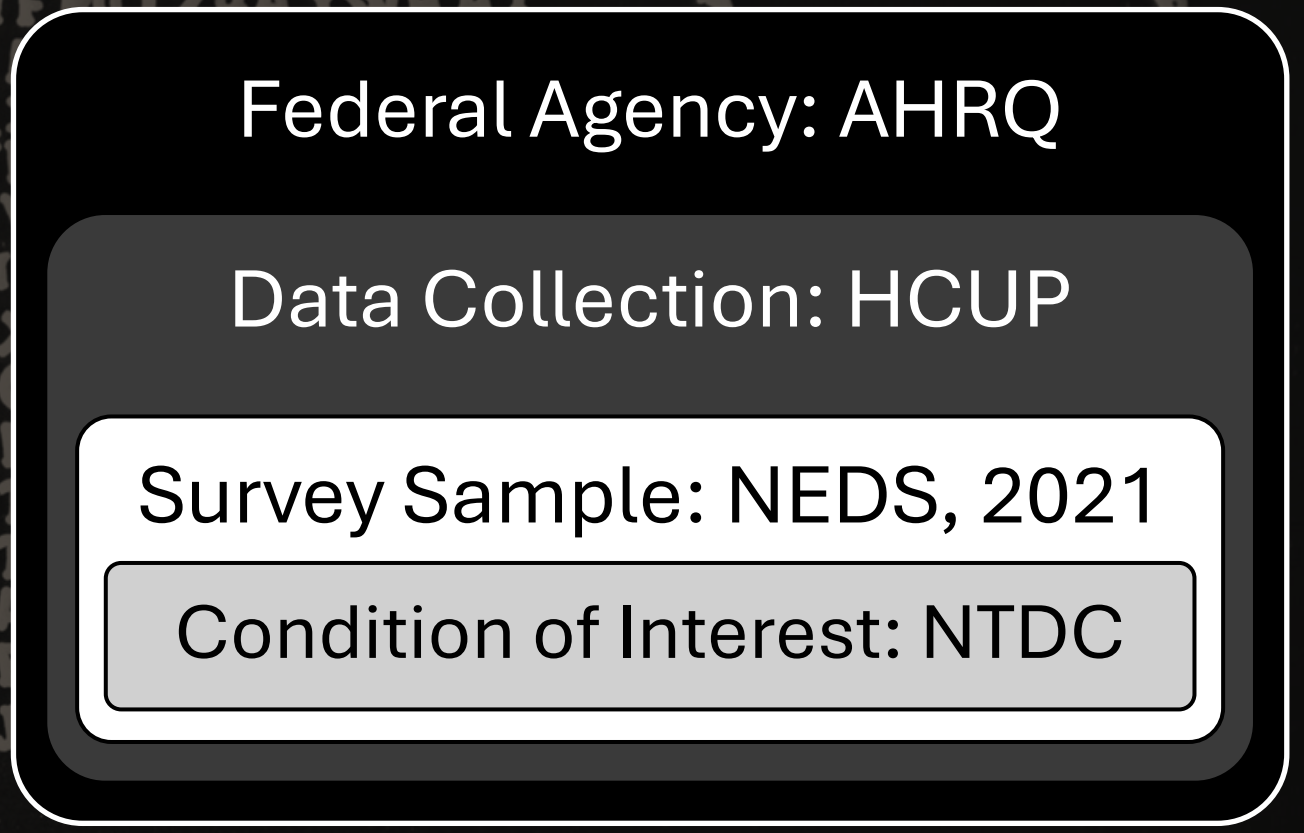
Further…

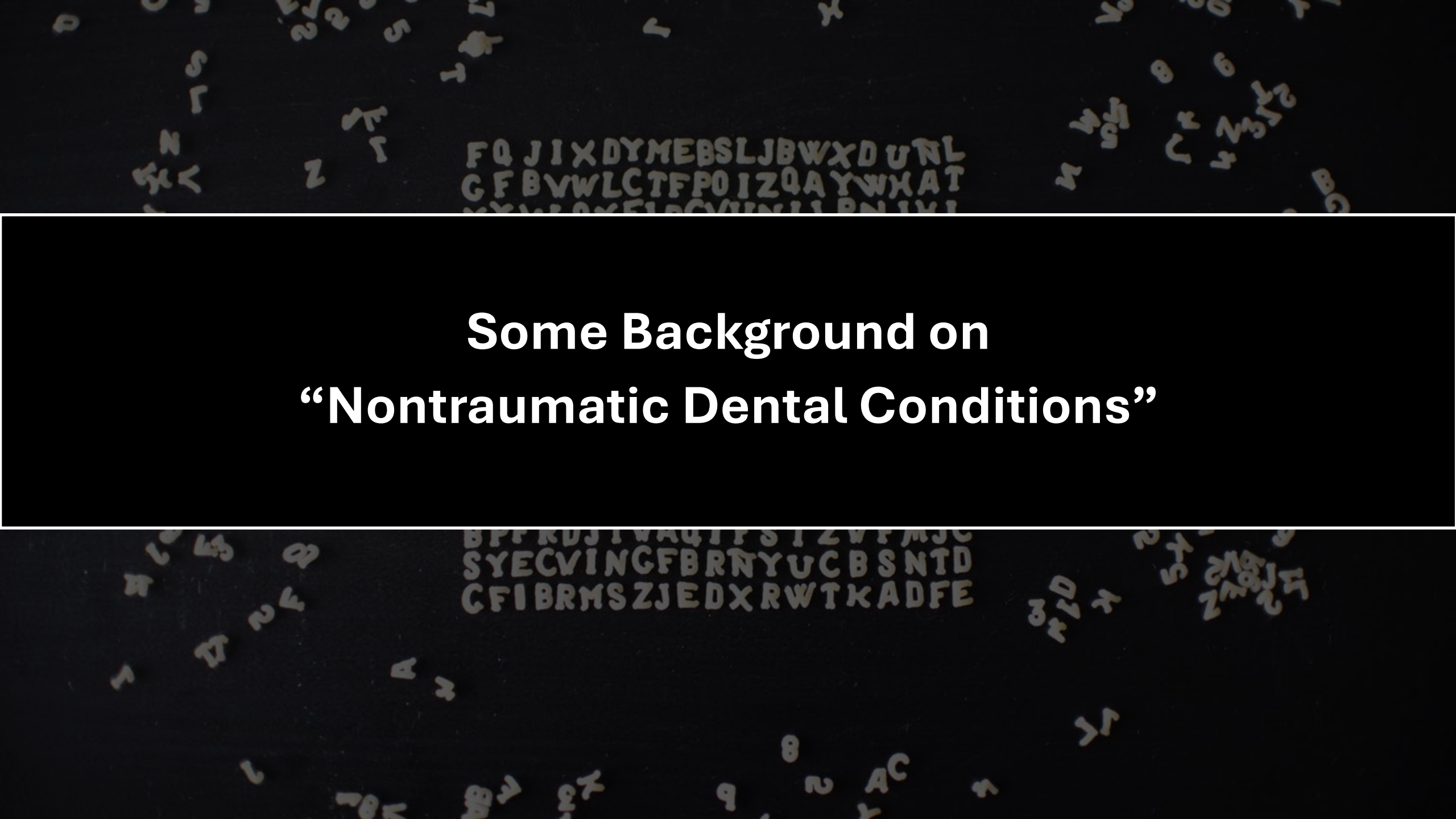
*Low-income communities, rural communities, and racial or ethnic minorities will be at **increased odds***

Project Scope

- Evaluating a large, nationally representative database →
  - Emergency department (ED) encounters →
    - Preventable dental encounters

- Nontraumatic dental conditions (NTDC)
- Nationwide Emergency Department Sample (NEDS)
- Healthcare Cost and Utilization Project (HCUP)
- US Agency for Healthcare Research and Quality (AHRQ)



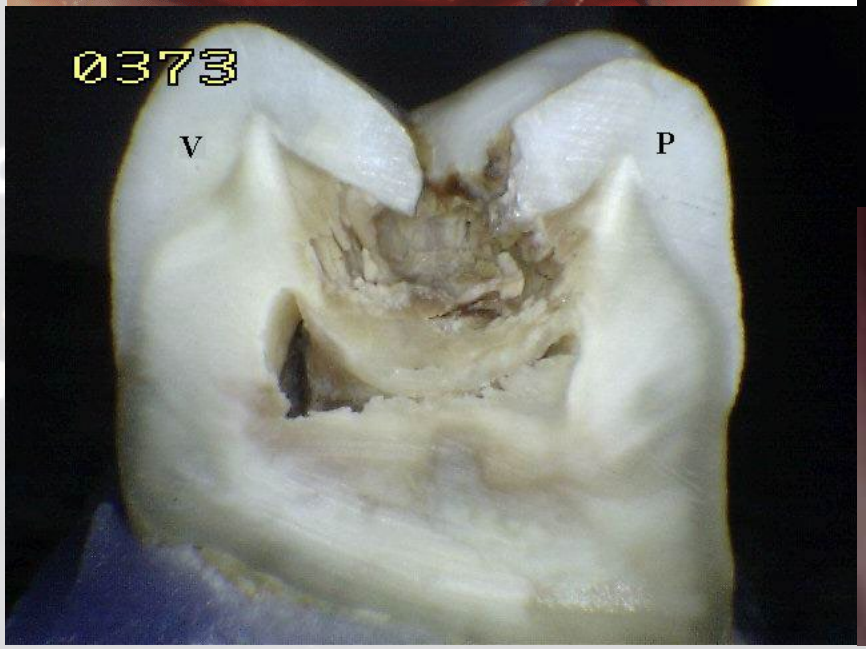


Some Background on “Nontraumatic Dental Conditions”

What is a nontraumatic dental condition?

It doesn’t stem from trauma;
It’s progressive and preventable;
It can become life-threatening if untreated.

Let’s see some visual examples…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What do we know so far?

- ED is a safety net for those unable to get routine dental care
- Leads to cyclical issue:
  - Antibiotics and analgesics may be provided
  - Barriers to care persist; Symptoms return
- Typically, no dentist or dental hygienist available in the ED
- NTDC are a preventable burden to the emergency care system

Who is particularly vulnerable?

- ✓ Low Socio-Economic Status
- ✓ Working age/non-elderly adults
- ✓ Uninsured or insured through public payers

- ? Inconclusive or Contradicting Evidence for:
  - ? Rural versus Urban centers
  - ? Male versus female
  - ? Race and Ethnicity Associations

Prevalence and cost:

Typically account for about 2% of all ED encounters

Approximately $500 million charged annually

Ultimately, why do we care?

Health System Burden

Patient Burden

Inequity in Population Health

Project Methods

Purpose and Aims

To assess for a relationship between key visit characteristics and ED encounters for nontraumatic dental conditions, using the most recent NEDS data release from AHRQ HCUP.

Nationwide Emergency Department Sample (NEDS)
Healthcare Cost and Utilization Project (HCUP)
Agency for Healthcare Research and Quality (AHRQ)

Study Design

- Secondary analysis of cross-sectional survey data
- Control encounter diagnoses used in the analysis with NTDC encounters
  - Logistic regression, “Domain analysis”
- NEDS: Stratified, single-stage cluster probability sample of encounter records from State ED reporting databases in 2021
  - Across 40 states and 993 hospitals
  - 30 million randomly selected encounters in the raw dataset
  - Weights provided for extrapolating nationwide estimates → 127 million encounters
- Note: Data are at **encounter level**, NOT patient level
  - Deidentified data set
  - No location data smaller than US census region and metropolitan status
  - Cannot provide insight into repeated visits by the same patients

Strengths of the NEDS dataset

- Extremely large survey sample size
- Very low missingness
  - Race and ethnicity – 3% missing values
  - Income Quartile – 2%
  - Many columns had zero missing values among 30 million rows!
- Research-quality curation by HCUP
  - Designed and collected for the purpose of research
    - Consistent formatting across collection years since 2006
    - User-friendly and comprehensive documentation provided by HCUP
  - Data now released up to year 2022
    - Collection ongoing *(as of 5/8/25)*

Independent Variables ("exposures/characteristics")

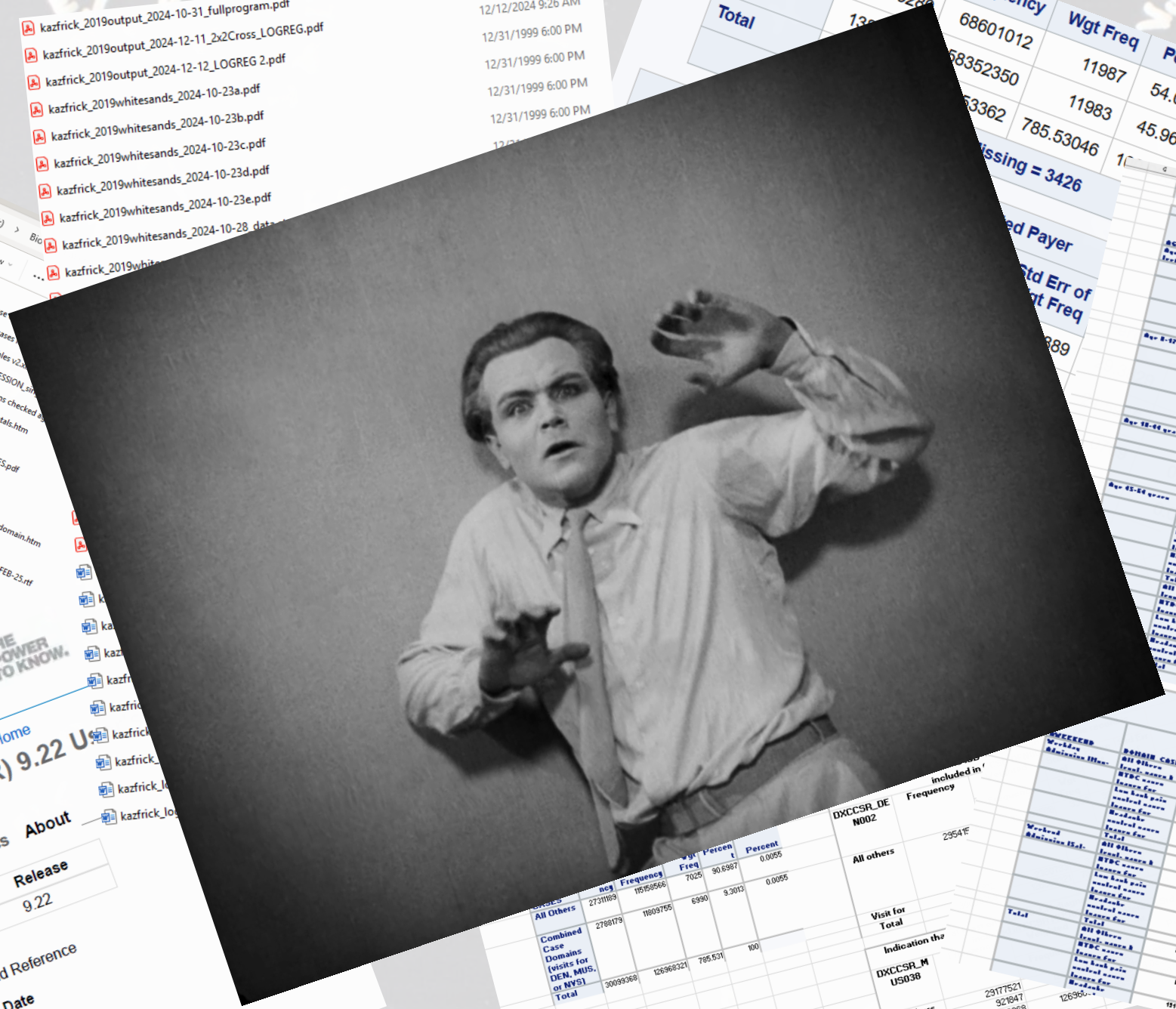
Study Variable	Levels
Sex	Female* Male
Age	0-17 years 18-44 years 45-64 years 65 years or greater*
Race and Ethnicity	Non-Hispanic White* Non-Hispanic Black Hispanic Other±
Income Quartile for Patient's Zip Code	1st Quartile ($1-51,999) 2nd Quartile ($52,000-65,999) 3rd Quartile ($66,000-87,999) 4th Quartile ($88,000+)*
Expected Primary Payer	Private Insurance* Medicare Medicaid No Insurance or Self-Pay
Patient Location	Urban* Rural

Indicates level set as reference category for statistical tests.

± Combines Asian or Pacific Islander, Native American, and Other

Dependent Variable ("outcome/event")

CCSR Diagnosis Group Code	CCSR Group Description	ICD-10 Codes	ICD-10-CM Description
Outcome (Case)			
DEN002	Nontraumatic Dental Conditions	K02.9	Dental caries, unspecified
		K03.81	Cracked tooth (non-traumatic)
		K03.9	Disease of the hard tissues of teeth, unspecified
		K04.6	Periapical abscess, with sinus
		K04.7	Periapical abscess, without sinus
		K04.9	Unspecified diseases of pulp & periapical tissues
Outcome (Control)			
MUS038	Low Back Pain	M54.5	Low back pain
		M54.50	Low back pain, unspecified
		M54.51	Vertebrogenic low back pain
		M54.59	Other low back pain
		M62.830	Muscle spasm of back
NVS010	Headache, including migraine	G43, G44 R51.0, R51.9	Migraine* Headache, orthostatic component Headache, unspecified



```
*-- DATA STEP 1: Trimming large tables ------------;
data
    dxgrp_2021_trim;
 set
    nedslib.neds_2021_dx_pr_grps
    (keep=
        KEY_ED
        DXCCSR_DIG002
        DXCCSR_DEN001
        DXCCSR_DEN002
        DXCCSR_DEN003
        DXCCSR_MUS038
        DXCCSR_NVS010);
 run;
```

```
data
    hospital_2021_trim;
 set
    nedslib.neds_2021_hospital
    (keep=
        HOSP_ED
        HOSP_REGION
        HOSP_CONTROL);
 run;
```

```
data
    thesis_2021_newvars;
 set
    merge_2021_tables;
        if DXCCSR_DEN002 > 0 AND DXCCSR_MUS038 = 0 then DOMAIN_MUS = 1;
        if DXCCSR_DEN002 = 0 AND DXCCSR_MUS038 > 0 then DOMAIN_MUS = 1;
        if DXCCSR_DEN002 = 0 AND DXCCSR_MUS038 = 0 then DOMAIN_MUS = 0;
        if DXCCSR_DEN002 > 0 AND DXCCSR_MUS038 > 0 then DOMAIN_MUS = 0;

        if DXCCSR_DEN002 > 0 AND DXCCSR_NVS010 = 0 then DOMAIN_NVS = 1;
        if DXCCSR_DEN002 = 0 AND DXCCSR_NVS010 > 0 then DOMAIN_NVS = 1;
        if DXCCSR_DEN002 = 0 AND DXCCSR_NVS010 = 0 then DOMAIN_NVS = 0;
        if DXCCSR_DEN002 > 0 AND DXCCSR_NVS010 > 0 then DOMAIN_NVS = 0;
```

```
data
    thesis_2021_cases;
 set
    thesis_2021_newvars;
        if DXCCSR_DEN002 > 0 then
            if DXCCSR_MUS038 = 0 AND DXCCSR_NVS010 = 0 then DOMAIN_CASES = 1;
        if DXCCSR_DEN002 > 0 then
            if DXCCSR_MUS038 > 0 AND DXCCSR_NVS010 > 0 then DOMAIN_CASES = 0;
        if DXCCSR_DEN002 > 0 then
            if DXCCSR_MUS038 > 0 AND DXCCSR_NVS010 = 0 then DOMAIN_CASES = 0;
        if DXCCSR_DEN002 > 0 then
            if DXCCSR_MUS038 = 0 AND DXCCSR_NVS010 > 0 then DOMAIN_CASES = 0;

        if DXCCSR_DEN002 = 0 then
            if DXCCSR_MUS038 > 0 AND DXCCSR_NVS010 = 0 then DOMAIN_CASES = 2;
        if DXCCSR_DEN002 = 0 then
            if DXCCSR_MUS038 = 0 AND DXCCSR_NVS010 > 0 then DOMAIN_CASES = 3;
        if DXCCSR_DEN002 = 0 then
            if DXCCSR_MUS038 > 0 AND DXCCSR_NVS010 > 0 then DOMAIN_CASES = 0;
        if DXCCSR_DEN002 = 0 then
            if DXCCSR_MUS038 = 0 AND DXCCSR_NVS010 = 0 then DOMAIN_CASES = 0;
    run;
```

```
data
    thesis_2021_data;
 set
    thesis_2021_cases;
        if AGE >=0 AND AGE <= 17 then AGE_cat = 1;
            else if AGE >= 18 AND AGE <=44 then AGE_cat = 2;
            else if AGE >=45 AND AGE <= 64 then AGE_cat = 3;
            else if AGE >= 65 then AGE_cat = 0;
 run;
```

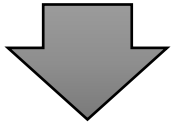
```
*--- Adding column labels to the new variables-----;

proc datasets;
    modify mylib.thesis_2021_data;
    label
        DOMAIN_MUS = 'Domain of DEN002 and MUS038 Visits'
        DOMAIN_NVS = 'Domain of DEN002 and NVS010 Visits'
        AGE_cat = 'Patient Age in Years'
        SEX_cat = 'Patient Sex'
        RACE_cat = 'Patient Race and Ethnicity'
        PAY_cat = 'Visit Primary Expected Payer'
        PL_NCHS_cat = 'Patient Location'
        HOSP_REGION_cat = 'Hospital Region in US'
        ZIPINC_cat = 'Income Quartile for Patient Zip Code'
        DEN002_cat = 'Nontraumatic Dental Visit'
        DOMAIN_CASES = 'Nontraum Dental, Low Back, or Headache Visit';
 run;
```

```
* ---- Log Reg Model 1: Among Dental & Low Back Pain Domain --------;
proc surveylogistic
    varmethod=TAYLOR
    data=
        mylib.thesis_2021_data;
    class
        AGE_cat (REF='Age 65+ years (ref)')
        SEX_cat (REF='Female (ref)')
        PAY_cat (REF='Private Insurance (ref)')
        PL_NCHS_cat (REF='Urban (ref)')
        RACE_cat (REF='White, non-hispanic (ref)')
        ZIPINC_cat (REF='Fourth Income Quartile (2021 $88,000+) (ref)');
    domain
        DOMAIN_MUS;
    model
        DEN002_cat
            (EVENT='Visits for Nontraumatic Dental') =
                AGE_cat
                Sex_cat
                PAY_cat
                PL_NCHS_cat
                RACE_cat
                ZIPINC_cat;
    format
        DOMAIN_MUS f_DOMAIN_M.
        DEN002_cat f_DEN002_cat.
        AGE_cat f_AGE_cat.
        SEX_cat f_SEX_cat.
        PAY_cat f_PAY_cat.
        PL_NCHS_cat f_PL_NCHS_cat.
        RACE_cat f_RACE_cat.
        ZIPINC_cat f_ZIPINC_cat.;
    strata
        NEDS_STRATUM;
    weight
        DISCWT;
    title "Inferential - Model 1: Dental & Low back pain population";
run;
```

Results

Study Sample Size:

- 3.8 million dental related visits (including trauma)
- 2.4 million visits for preventable dental conditions



- 2.2 million visits were included in the study as “NTDC cases”

Descriptive Results:

- 2,243,696 included NTDC encounters (2% of total encounters)
  - low back pain=3,714,011 (3%); headaches=5,560,632 (4%)

- Within NTDC encounters, a greater proportion of patients…
  - aged 18-44 (50%),
  - non-Hispanic White patients (54%),
  - patients living in Zip Codes within the lowest income quartile (40%),
  - Medicaid as the primary payer (40%), and
  - within urban hospital EDs (80%)

- 51% of encounters were for female patients

Weighted Counts Shown per 1,000	All other ED Encounters n=115,450	NTDC Encounters n=2,244	Low Back Pain Encounters n=3,714	Headache Encounters n=5,561
Sex				
Female	61,517 (53)	**1,149 (51)**	2,104 (57)	3,832 (69)
Male	53,919 (47)	**1,095 (49)**	1,610 (43)	1,728 (31)
Age				
0-17 years	19,613 (17)	**376 (17)**	74 (2)	508 (9)
18-44 years	42,235 (37)	**1,133 (50)**	1,349 (36)	2,646 (48)
45-64 years	27,508 (24)	**476 (21)**	1,302 (35)	1,580 (28)
65 years +	26,091 (23)	**259 (12)**	989 (27)	826 (15)
Race & Ethnicity				
Non-Hispanic White	62,482 (56)	**1,152 (54)**	2,063 (57)	2,822 (52)
Non-Hispanic Black	21,999 (20)	**556 (26)**	788 (22)	1,173 (22)
Hispanic	19,827 (18)	**316 (15)**	585 (16)	1,062 (20)
Other	7,344 (7)	**127 (6)**	199 (5)	346 (6)

Weighted Counts Shown per 1,000	All other ED Encounters n=115,450	NTDC Encounters n=2,244	Low Back Pain Encounters n=3,714	Headache Encounters n=5,561
Income Quartile for Patient's Zip Code				
1st Quartile	38,699 (34)	**872 (40)**	1,297 (36)	1,864 (34)
2nd Quartile	30,121 (27)	**616 (28)**	968 (26)	1,413 (26)
3rd Quartile	25,047 (22)	**440 (20)**	802 (22)	1,229 (22)
4th Quartile	19,518 (17)	**276 (13)**	586 (16)	964 (18)
Expected Primary Payer				
Private Insurance	33,733 (29)	**482 (22)**	1,072 (29)	1,965 (35)
Medicare	28,649 (25)	**340 (15)**	1,136 (31)	1,056 (19)
Medicaid	35,834 (31)	**947 (42)**	911 (25)	1,709 (31)
No Insurance/ Self-Pay	17,066 (15)	**470 (21)**	591 (16)	822 (15)
Patient Location				
Urban	94,185 (82)	**1,790 (80)**	3,032 (82)	4,639 (84)
Rural	20,350 (18)	**437 (20)**	661 (18)	886 (16)

Summary of Logistic Regression Analysis:

- Increased odds persisting in both models were found for:
  - male patients,
  - patients 18-44 years old,
  - patients living in communities within the 1st and 2nd income quartiles,
  - rural hospitals,
  - and with Medicaid as the primary payer for NTDC encounters.
- Regarding race and ethnicity, both models showed that:
  - Hispanic patients had a decreased likelihood of visiting the ED for NTDC, and
  - non-Hispanic Black patients had an equal likelihood as non-Hispanic White patients.

	Model 1: NTDC & Low-Back Pain	Model 2: NTDC & Headache
	OR (95% CI)	OR (95% CI)
Sex		
Female	1.00	1.00
Male	1.24 (1.23, 1.24)	2.06 (2.04, 2.07)

Increased odds for males in both models

	Model 1: NTDC & Low-Back Pain	Model 2: NTDC & Headache
	OR (95% CI)	OR (95% CI)
Age		
0-17 years	14.1 (13.7, 14.4)	1.84 (1.81, 1.88)
18-44 years	2.62 (2.58, 2.66)	1.19 (1.17, 1.21)
45-64 years	1.23 (1.21, 1.25)	0.90 (0.89, 0.92)
65 years or greater	1.00	1.00

Increased odds for 18-44 age group;
Odds likely increased for those under 17*;
Odds for 45-64 group inconclusive/non-significant*

*Would want to reanalyze age under different domain to see if that is the cause

	Model 1: NTDC & Low-Back Pain	Model 2: NTDC & Headache
	OR (95% CI)	OR (95% CI)
Race & Ethnicity		
Non-Hispanic White	1.00	1.00
Non-Hispanic Black	1.00 (0.99, 1.01)	0.99 (0.99, 1.00)
Hispanic	0.68 (0.67, 0.69)	0.62 (0.61, 0.63)
Other	0.94 (0.92, 0.96)	0.86 (0.85, 0.87)

Decreased odds for Hispanic group & “Other”;

Same odds for Black as White in both domains

	Model 1: NTDC & Low-Back Pain	Model 2: NTDC & Headache
	OR (95% CI)	OR (95% CI)
Income Quartile for Patient's		
1st Quartile	1.14 (1.12, 1.15)	1.31 (1.29, 1.32)
2nd Quartile	1.14 (1.13, 1.16)	1.31 (1.29, 1.32)
3rd Quartile	1.05 (1.04, 1.07)	1.15 (1.14, 1.17)
4th Quartile	1.00	1.00

Increased odds for 1st and 2nd Income Quartiles

Q1 = $0-51,999; Q2 = $52,000-64,999

Median Household income 2021 = $71,000

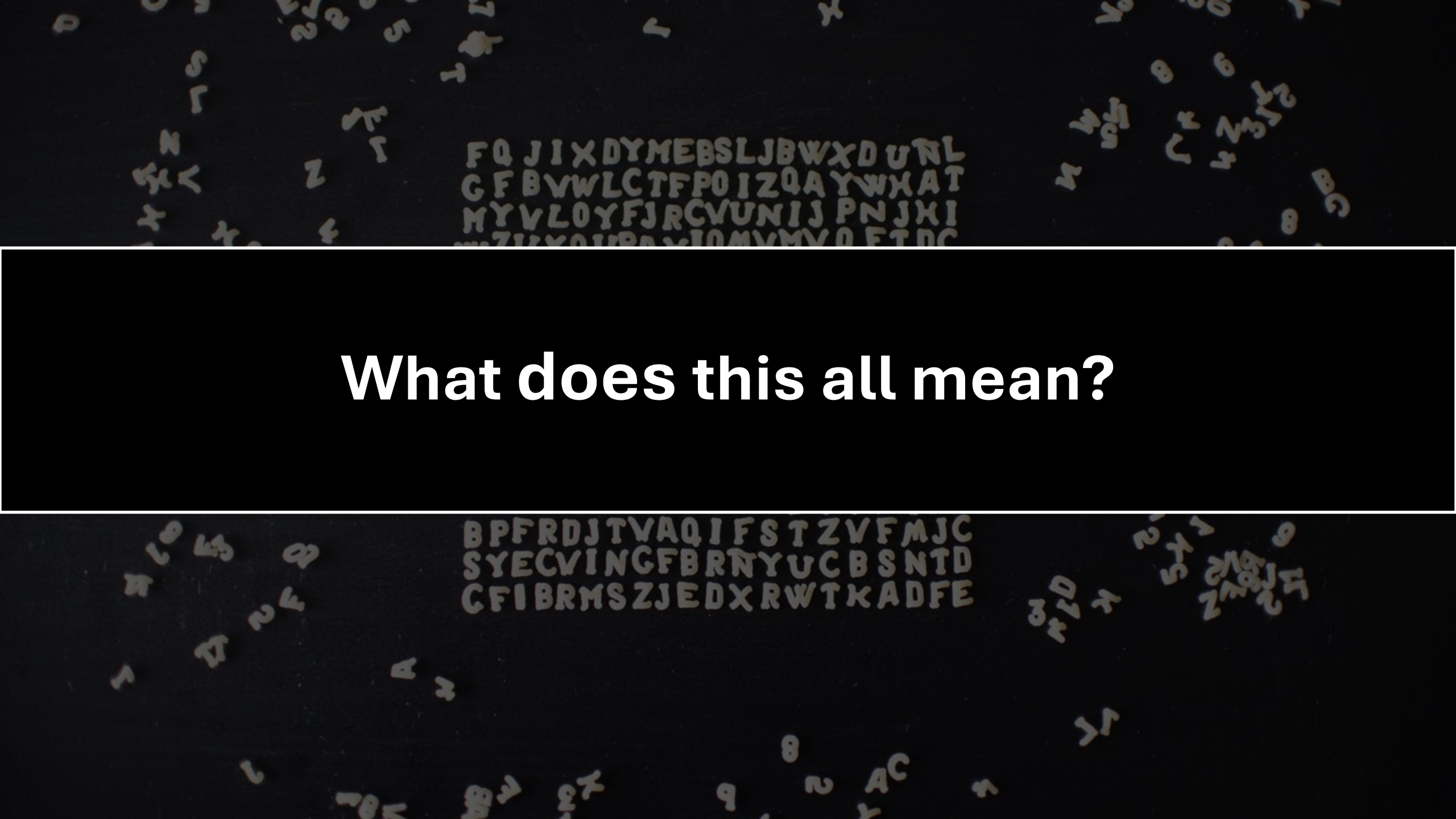
	Model 1: NTDC & Low-Back Pain	Model 2: NTDC & Headache
	OR (95% CI)	OR (95% CI)
Expected Primary Payer		
Private Insurance	1.00	1.00
Medicare	1.20 (1.18, 1.22)	1.47 (1.45, 1.49)
Medicaid	1.82 (1.80, 1.84)	2.11 (2.09, 2.13)
No Insurance/ Self-Pay	1.64 (1.63, 1.66)	2.11 (2.09, 2.13)

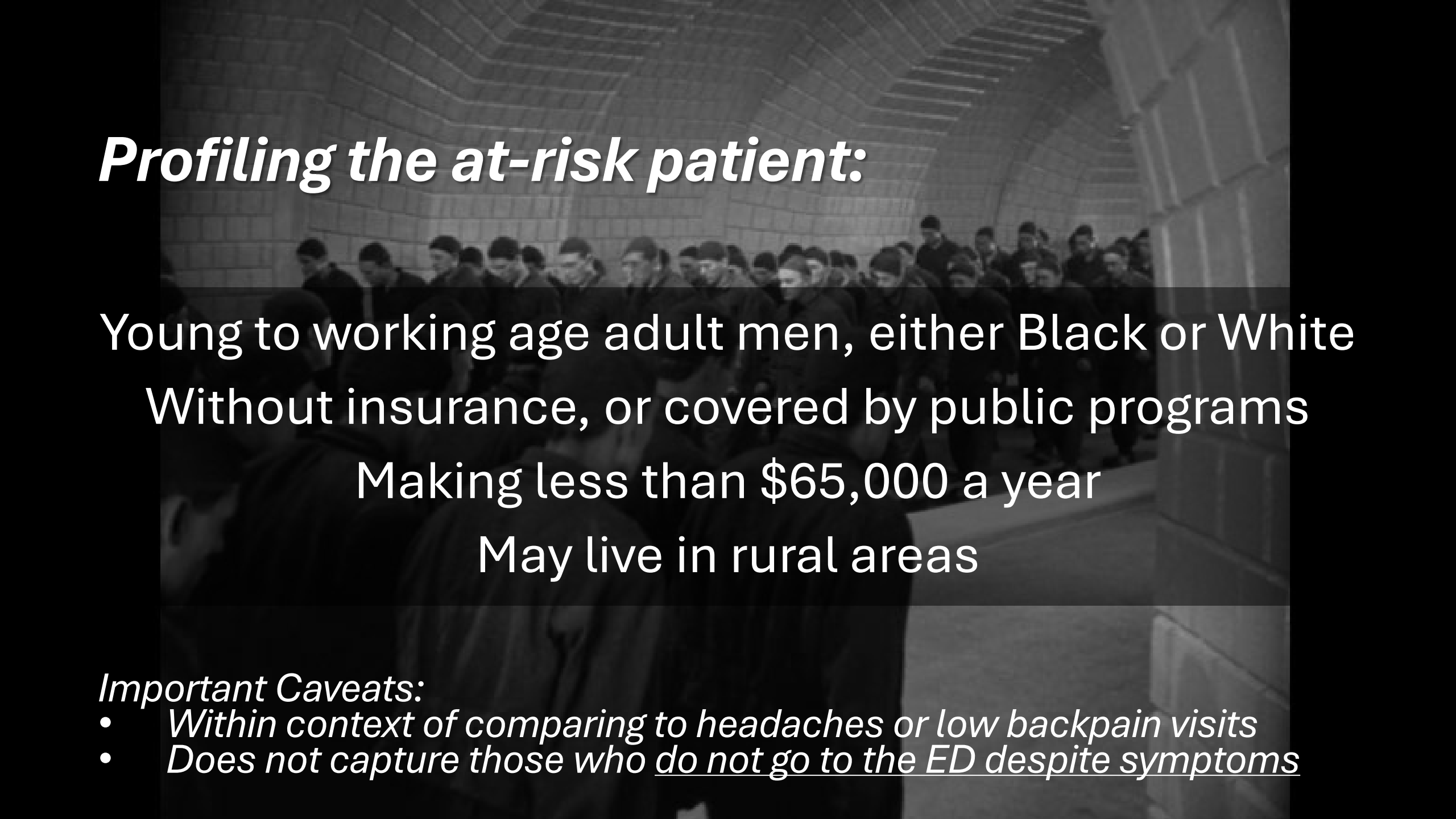
Increased odds for public insurance payers, particularly Medicaid

Increased odds for those without any coverage

	Model 1: NTDC & Low-Back Pain	Model 2: NTDC & Headache
	OR (95% CI)	OR (95% CI)
Patient Location		
Urban	1.00	1.00
Rural	1.10 (1.08, 1.11)	1.14 (1.12, 1.15)

Slight increase in odds for rural zip codes


What does this all mean?



Profiling the at-risk patient:

Young to working age adult men, either Black or White

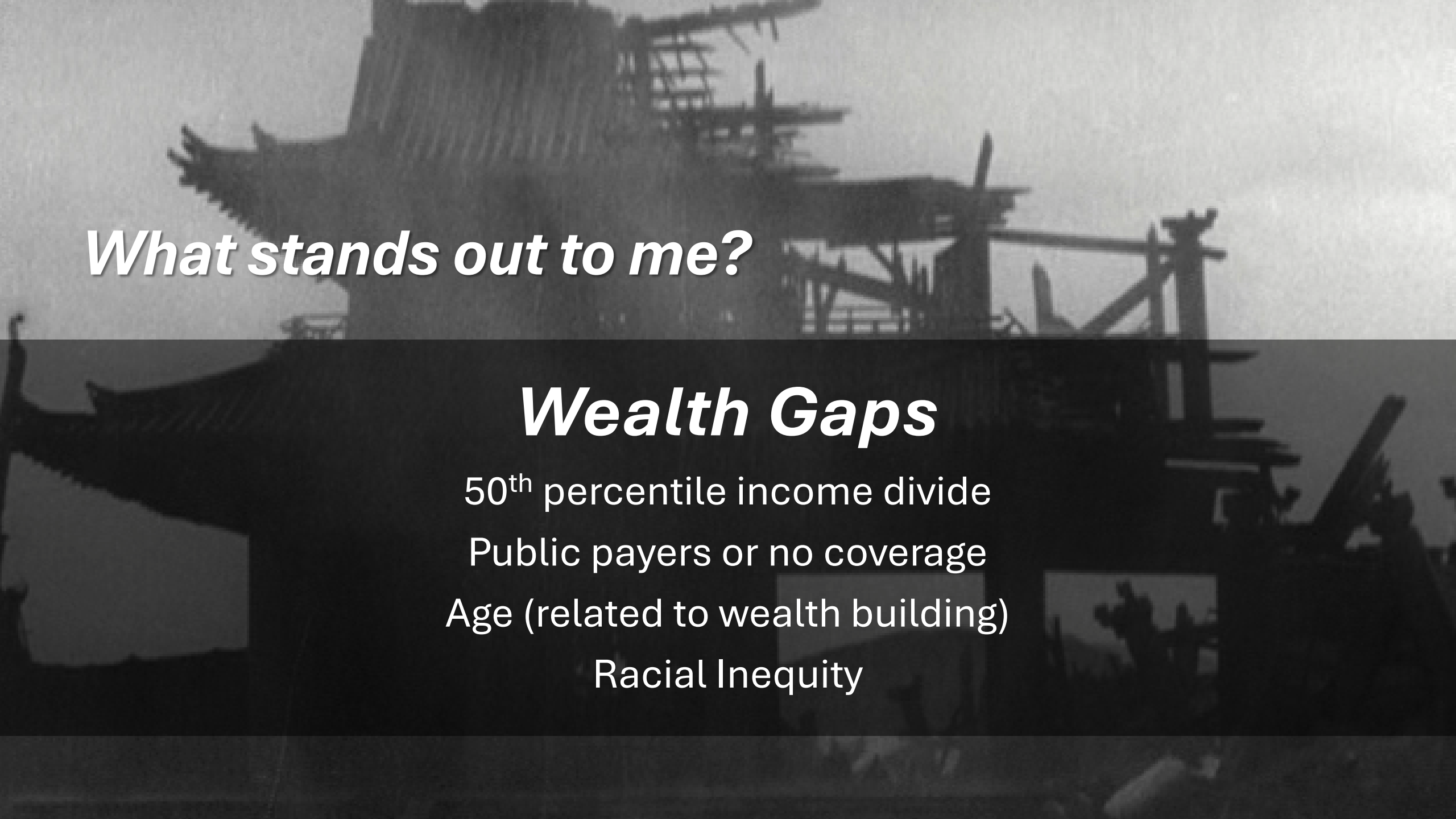
Without insurance, or covered by public programs

Making less than $65,000 a year

May live in rural areas

Important Caveats:

- *Within context of comparing to headaches or low backpain visits*
- *Does not capture those who do not go to the ED despite symptoms*



What stands out to me?

Wealth Gaps

50th percentile income divide

Public payers or no coverage

Age (related to wealth building)

Racial Inequity

Strengths and Limitations

Strengths

- Robust data source, random stratified sample
  - Huge sample size
  - Very low missingness
  - Very narrow 95% confidence intervals
- Representative of real-world encounters
- Multiple comparison diagnoses provide nuanced context for results

Limitations

- Retrospective research:
  - Using Survey Data
  - Using Electronic Health Records
- Deidentified data
  - Unable to track repeated visits by individual patients
  - Unable to identify trends smaller than US region or general rural-urban status
- Choice of comparison groups, no perfect control
  - Some uneven distribution of characteristics between models
  - **Using two groups mitigates this limitation somewhat**

In Summary

- Non-traumatic dental conditions (NTDCs) are a preventable burden on US EDs (time, money, labor, beds)
- EDs are not able to provide definitive care to resolve NTDCs
- EDs remain a safety net for vulnerable populations unable to get routine dental care, such as young working men and those earning under median income


Where do we go from here?