Using Predictive Analytics to Inform Policy and Practice About Children and Families That Use a High Level of Services: Applying Predictive Modeling, Latent Class Analysis, and Other Techniques to Predict Superutilization of Child Welfare, Health, and Other Services

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• Tennessee site partners
  – Department of Children’s Services, TennCare

• Florida site partners
  – Department of Children and Families, Agency for Healthcare Administration, Eckerd Kids
Unaddressed Needs

- About 437,000 children are in foster care
- Children in foster care are eligible for Medicaid
- Nearly a billion Medicaid dollars are spent annually on youth in foster care
- Data sharing across Medicaid and child welfare is rare despite being primary service providers.
- Children in foster care account for a disproportionate amount of Medicaid expenditures for behavioral health.
Study Innovations and Contributions

- Cross-sector Collaboration
- Administrative Data
- Sophisticated analytics
- Holistic View of Service Use
- Actionable Evidence
Research Questions

1. What is superutilization of child welfare and other services? What distinguishes children who experience superutilization?

2. Are there different types of superutilization?

3. What characteristics of children at time of entry into out-of-home custody predict superutilization?
Project Sites and Data Partners

Tennessee:

Hillsborough, Pinellas & Pasco Counties, Florida:
Data Sources and Linking

Tennessee Department of Children’s Services
Child Welfare

- TennCare
- Medicaid Claims

Florida Department of Children and Families
Child Welfare

- Agency for Health Care Administration
  - Medicaid Claims

  Florida Department of Children and Families
  Substance Abuse and Mental Health Program Services

  Eckerd Kids/Child Welfare Community-Based Care Purchased Services
Study Samples

- Descriptive and latent class analysis sample
  - Tennessee
    - Children entering out-of-home custody between:
      - July 1, 2011 – Dec 31, 2015
        - N = 21,672
      - July 1, 2012 – Jan 1, 2014
        - N = 12,056
  - Hillsborough, Pinellas, and Pasco Counties, Florida
    - Children entering out-of-home custody between:
        - N = 6,695
      - Jan 1, 2012 – Jan 1, 2014
        - N = 8,290

- Predictive analysis sample
Child Welfare, Medicaid and Other Services

Tennessee:
Service receipt among study sample while in child welfare custody:
• 84.1% received child welfare services
• 85.6% received Medicaid services

Hillsborough, Pinellas, and Pasco Counties (Florida):
Service receipt among study sample while in child welfare custody:
• 19.8% received child welfare community-based care (CBC) purchased services
• 91.5% received Medicaid services
• 15.8% received other substance abuse or mental health
Measurement of Superutilization

**SERVICE TYPE**

- Medicaid
- SAMH
- Child Welfare

**UTILIZATION DIMENSION**

- Intensity
- Cost
- Duration
- Frequency

**SAMH**: Substance Abuse and Mental Health data in Florida.
Other Measurement Considerations

- Establishing a threshold:
  - Used a 90th percentile threshold to identify superutilization

- Address influence of age on service utilization:
  - Calculated threshold by age

- Address exposure to study window:
  - Calculated annualized rates using service use among time in child welfare custody
<table>
<thead>
<tr>
<th>Measure of superutilization</th>
<th>TN Study Sample n=21,672</th>
<th>FL Study Sample n=6,695</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number (Percent)</td>
<td>Number (Percent)</td>
</tr>
<tr>
<td>Total number of episodes</td>
<td>3,190 (14.7%)</td>
<td>894 (13.4%)</td>
</tr>
<tr>
<td>Total number of placement moves</td>
<td>3,387 (15.6%)</td>
<td>1,078 (16.1%)</td>
</tr>
<tr>
<td>Total placement cost per year</td>
<td>2,552 (11.8%)</td>
<td>N.A.</td>
</tr>
<tr>
<td>Total episode length of stay</td>
<td>2,722 (12.6%)</td>
<td>740 (11.1%)</td>
</tr>
<tr>
<td>Average proportion of time in congregate care/residential/group home</td>
<td>1,827 (8.4%)</td>
<td>609 (9.1%)</td>
</tr>
<tr>
<td>Child welfare/CBC purchased services per year</td>
<td>2,432 (11.2%)</td>
<td>601 (9.0%)</td>
</tr>
<tr>
<td>Child welfare/CBC purchased services cost per year</td>
<td>1,789 (8.3%)</td>
<td>567 (2.6%)</td>
</tr>
<tr>
<td>Medicaid inpatient services per year</td>
<td>1,257 (5.8%)</td>
<td>380 (5.7%)</td>
</tr>
<tr>
<td>Medicaid outpatient services per year</td>
<td>2,261 (10.4%)</td>
<td>762 (5.7%)</td>
</tr>
<tr>
<td>Medicaid emergency services per year</td>
<td>2,213 (10.2%)</td>
<td>380 (5.7%)</td>
</tr>
<tr>
<td>Mental health services per year</td>
<td>N.A.</td>
<td>560 (8.5%)</td>
</tr>
<tr>
<td>Substance abuse services per year</td>
<td>N.A.</td>
<td>262 (3.9%)</td>
</tr>
<tr>
<td>Total children identified by any measure of superutilization</td>
<td>12,332 (56%)</td>
<td>3,726 (55%)</td>
</tr>
</tbody>
</table>
Analysis Approach

Two phases of the analysis:

1. Descriptive and latent class analyses:
   - Describe characteristics of high service use
   - Identify types (latent classes) of superutilization
   - Describe characteristics related to each type of superutilization

2. Predictive analysis:
   - Assess predictive factors for risk of superutilization (placement instability) at time of entry into foster care
Overview of Latent Class Analysis

• **Use latent class analysis to identify types of superutilization**
  - Statistical method for grouping observations (children) into distinct groups or “classes” based on observed variables (superutilization measures)
  - Allows us to examine distinct combinations of superutilization patterns that may define a given class
  - Ultimately, individual membership in a latent class is based on probabilistic assignment
  - Classes are defined based on how clearly variables are associated with those classes (probabilities close to one or zero) clearly differentiate classes.
## Types of Superutilization: Latent Class Results for TN

### 7 classes of superutilization:

<table>
<thead>
<tr>
<th>Class Name</th>
<th>Description</th>
<th>Percentage of Superutilization population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>Foster care placement instability</td>
<td>23.0%</td>
</tr>
<tr>
<td>Class 2</td>
<td>Multiple foster care episodes</td>
<td>12.2%</td>
</tr>
<tr>
<td>Class 3</td>
<td>Child welfare service use</td>
<td>21.5%</td>
</tr>
<tr>
<td>Class 4</td>
<td>Duration in foster care</td>
<td>7.3%</td>
</tr>
<tr>
<td>Class 5</td>
<td>Medicaid outpatient service use</td>
<td>9.1%</td>
</tr>
<tr>
<td>Class 6</td>
<td>Medicaid emergency service use</td>
<td>8.6%</td>
</tr>
<tr>
<td>Class 7</td>
<td>Use of group/congregate care placements and high placement costs</td>
<td>18.1%</td>
</tr>
</tbody>
</table>

**Total percentage of superutilizers** 100.0%
Overview of Tennessee Latent Classes

Class 1: Foster care placement instability

Class 2: Multiple foster care episodes

Class 3: Child welfare service use

Class 4: Duration in foster care

Class 5: Medicaid outpatient service use

Class 6: Medicaid emergency service use

Class 7: Use of group/congregate care placements and placement costs

Superutilization Measure:
- Total number of episodes
- Total episodes length of stay
- Total number of placement moves
- Total placement cost per year
- Percent of time in group/congregate care placements
- Child welfare services per year
- Child welfare service cost per year
- Medicaid inpatient per year
- Medicaid outpatient per year
- Medicaid emergency per year
TN Class 1: Foster Care Placement Instability

• Defining characteristics:
  – High number of foster care placement moves (54.7% had 7 or more placement moves)

• Other key findings:
  – 92% received child welfare services and among those receive services:
    • 71.4% received clothing assistance
    • 28.9% received substance abuse testing and treatment
    • 22.8% received family and parenting support services
  – For reasons for removal:
    • 42.6% had neglect
    • 39.1% had parent drug abuse
    • 14.9% had physical abuse as a reason for removal (which was the highest proportion across all classes)
  – 62.0% exited custody with 48.1% being reunified and 23.8% adopted
# Types of Superutilization: Latent Class Results for FL

## 8 classes of superutilization:

<table>
<thead>
<tr>
<th>Class Name</th>
<th>Description</th>
<th>Percentage of Superutilization population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>Child welfare CBC purchased services use</td>
<td>14.0%</td>
</tr>
<tr>
<td>Class 2</td>
<td>Complex child welfare and Medicaid service use</td>
<td>5.4%</td>
</tr>
<tr>
<td>Class 3</td>
<td>Medicaid and mental health service use</td>
<td>23.2%</td>
</tr>
<tr>
<td>Class 4</td>
<td>Foster care placement instability</td>
<td>10.2%</td>
</tr>
<tr>
<td>Class 5</td>
<td>Multiple foster care episodes</td>
<td>19.9%</td>
</tr>
<tr>
<td>Class 6</td>
<td>Duration in foster care</td>
<td>5.6%</td>
</tr>
<tr>
<td>Class 7</td>
<td>Use of group home/residential treatment placements</td>
<td>8.8%</td>
</tr>
<tr>
<td>Class 8</td>
<td>Medicaid emergency services use</td>
<td>12.8%</td>
</tr>
</tbody>
</table>

**Total percentage of superutilizers** 100.0%
Overview of Florida Latent Classes

Class 1: Child welfare service use
Class 2: Complex child welfare and Medicaid service use
Class 3: Medicaid and mental health service use
Class 4: Foster care placement instability
Class 5: Multiple foster care episodes
Class 6: Duration in foster care
Class 7: Use of group/residential care placements
Class 8: Medicaid emergency services use

Superutilization Measure:
- Total number of episodes
- Out-of-home episode length of stay
- Total number of placement moves
- Percent of time in group/residential placements
- Child welfare services per year
- Child welfare service cost per year
- Medicaid inpatient per year
- Medicaid outpatient per year
- Medicaid emergency per year
- Mental health services per year
- Substance abuse services per year

MATHEMATICA Policy Research
FL Class 4: Foster Care Placement Instability

• Defining characteristics:
  – High numbers of foster care placement moves (average of 6.4)

• Key findings:
  – **59.6% are less than 1 year old**, and 28.6% are between 1-5 years old
  – Only 3.9% had a prior custody episode
  – 16.8% received child welfare services
  – **55.4% exited custody**
    • 64.9% were reunified
    • 27.5% were adopted
Predicting Superutilization: Predictive Analysis Results
Goals of Predictive Analysis

• Predict risk of superutilization within 12 months of entering an out-of-home custody episode
  – Predictive outcome: Superutilization defined as a high number of placement moves within an out-of-home custody episode (also referred to as placement instability)
  – 12-month predictive time period and look-back time period

• Assess overall predictive accuracy

• Explore what predictive factors are most important
  – Child characteristics
  – Reasons for removal, assessments/risk level
  – Prior child welfare history (investigations, episodes, placements)
  – Prior child welfare, Medicaid, and substance abuse/mental health service use
Structuring the Data: Study Sample and Prediction Period

Qualifying sample:

- **Florida**: Children entering out-of-home custody with a start date between January 1, 2012, and December 1, 2014 (N = 8,290)
- **Tennessee**: Children entering out-of-home custody with start date between July 1, 2012, and December 1, 2014 (N = 12,056)
Measuring Superutilization

<table>
<thead>
<tr>
<th>State</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>P90 superutilization threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Florida</td>
<td>3.3</td>
<td>4.3</td>
<td>5</td>
</tr>
<tr>
<td>Tennessee</td>
<td>2.6</td>
<td>1.7</td>
<td>4</td>
</tr>
</tbody>
</table>

- Number of placement moves (placement instability) during the 12-month prediction period
  - Superutilization was defined as youth who equaled or exceeded the 90th percentile value for total number of placement moves within the t0 episode
  - For Florida, 14 percent of the sample met/exceeded the threshold (5 placement moves)
  - For Tennessee, 20 percent of the sample met/exceed the threshold (4 placement moves)
Model Development

- Randomly split the full data into “training” and “test” data sets.
  - 70% of the sample used for the training set
  - 30% of the sample used for the test set

- Choose predictor variables
## Types of Variables Used for Prediction

<table>
<thead>
<tr>
<th>Variable domain</th>
<th>Florida</th>
<th>Tennessee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child demographic characteristics</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Prior investigations</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Reasons for removal</td>
<td>─</td>
<td>✓</td>
</tr>
<tr>
<td>Foster care placements</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Child welfare custodial episodes</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Child welfare services</td>
<td>─</td>
<td>✓</td>
</tr>
<tr>
<td>Child welfare assessments</td>
<td>─</td>
<td>✓</td>
</tr>
<tr>
<td>Child welfare investigation average recommended service level</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Substance abuse and mental health services/assessments</td>
<td>✓</td>
<td>─</td>
</tr>
<tr>
<td>Medicaid services</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Regional composition</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
Compare Predictive Modeling Approaches

- Logistic Regression with Elastic Net
- K-nearest Neighbors
- Random Forests
Predictive Performance of Random Forest Model

<table>
<thead>
<tr>
<th>State</th>
<th>Model performance metrics</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area Under the Curve (AUC)</td>
<td>Sensitivity</td>
<td>Specificity</td>
<td>Accuracy</td>
<td>Positive Predictive Value (PPV)</td>
</tr>
<tr>
<td>Florida</td>
<td>0.722</td>
<td>0.589</td>
<td>0.777</td>
<td>0.750</td>
<td>0.304</td>
</tr>
<tr>
<td>Tennessee</td>
<td>0.727</td>
<td>0.682</td>
<td>0.671</td>
<td>0.673</td>
<td>0.342</td>
</tr>
</tbody>
</table>

- **Area Under the Curve (AUC).** How well the predictive model correctly classifies children who experience superutilization compared to children who do not. Higher values on the AUC indicate better prediction. AUC values greater than 0.7 are typically considered to indicate good predictive performance.

- **Sensitivity.** The ability of the model to correctly identify children who experience superutilization.

- **Specificity.** The ability of the model to correctly identify children who do not experience superutilization.

- **Accuracy.** Agreement between children’s superutilization classification, as predicted by the model, compared to their actual classification (weighted by the prevalence of superutilization).

- **Positive Predictive Value (PPV).** The probability that a child classified as experiencing superutilization actually does experience superutilization.

- **Negative Predictive Value (NPV).** The probability that a child classified as *not* experiencing superutilization actually does not experience superutilization.
Most Important Predictors

• Key question: Among the variables used for prediction, which are most important?
  – Florida: 53 variables
  – Tennessee: 65 variables

• For the random forest model, we can assess variable importance using the Gini impurity index
Tennessee: Top 8 Most Important Predictors

- Age at entry into out-of-home placement
- Number of prior child welfare investigations
- Medicaid outpatient physical health services
- Medicaid outpatient behavioral health services
- Medicaid emergency physical health services
- Reason for removal: Child's behavioral problem
- Total length of stay in prior foster care episodes
- Number of noncustodial child welfare services

Source: Tennessee DCS; TennCare; American Community Survey 2015; U.S. Census 2010.
Tennessee Results: Age

- Older children are at greater risk of placement instability; the largest change in the predicted probability of placement instability occurs between ages 11 and 12.
Tennessee Results: Medicaid Outpatient Behavioral Health Services

- Prior receipt of one or two Medicaid outpatient behavioral health services is associated with the largest change in the probability of placement instability.
Florida: Top 10 Most Important Predictors

- Age at entry into out-of-home placement
- Total length of stay in prior placements
- Number of prior child welfare investigations
- Medicaid outpatient physical health services
- Medicaid outpatient behavioral health services
- Medicaid emergency physical health services
- SAMHIS substance abuse services
- Medicaid inpatient behavioral health services
- Number of prior child welfare episodes
- SAMHIS mental health services

Source: Florida DCF; Florida AHCA data; Florida SAMH; American Community Survey 2015; Census 2010.
Florida Results: Age

- Older children are at greater risk of placement instability; the largest change in the predicted probability of placement instability occurs between ages 11 and 12.
Florida Results: Medicaid Outpatient Behavioral Health Services

• The number of outpatient behavioral health services received via Medicaid during the lookback period slightly increases the chances of placement instability.

![Graph showing the relationship between the number of Medicaid outpatient behavioral health services and the chances of placement instability.](image-url)
Implications, Recommendations, and Research Evidence Use
Implications

Study results suggest further exploration:

• Some prior referrals may not be addressed well enough.

• Need to focus on children with prior child welfare involvement and those using a large amount of ER services
  – Specifically on whether prior issues that have not been resolved

• Some children have comorbid conditions (multiple behavioral health problems) or more severe behavioral health problems.

• SAMH-funded substance abuse and mental health service usage in Florida
  – Are service gaps in the Medicaid and child welfare delivery systems are causing delays in treatment?
Recommendations (1)

• Child welfare agencies can:
  – Support foster parents to care for children with behavioral health needs
  – See child welfare investigations as a window of opportunity to meet family needs
  – Conduct case record reviews and case consultation for youth at high risk of placement instability
  – Hire mental health and early childhood consultants in child welfare agencies
Recommendations (2)

• Medicaid agencies can:
  – Conduct behavioral health screening for all young children entering foster care
  – Develop collaborative treatment plans with child welfare
  – Monitor performance of providers and gaps in service delivery

• Child welfare agencies in collaboration with other providers can:
  – Implement early interventions for children at high risk for placement instability
  – Obtain federal approval use Medicaid to reimburse evidence-based programs
Action Plan Priorities:

• Recruitment and retention of therapeutic foster care providers to reduce placement instability and use of group care

• Engage provider community

Action Plan Priorities:

• Case record review of young children going to ER for physical health issues

• Identify service gaps

• Foster more collaboration between state child welfare and Medicaid departments
Dissemination

- Studying findings to be available early March 2018
  - Final report
  - Executive summary
  - Web-based brief
Audience Questions and Discussion
Thank you!