Predictive Analytics in Child Welfare Using the Child and Adolescent Needs and Strengths (CANS)

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Overview

• **Background**
  • Illinois child welfare system
  • Use of the CANS
  • Predictive analytics

• **Predictive analytic studies**
  • Psychiatric hospitalization
  • Residential placement

• **Implications on implementation and practice**

• **Discussion**
Illinois Child Welfare System

• Lowest removal rate in the country (1.5 children per 1,000 children in the general population)\(^1\)
• >2 times the national median stay (>13.5 months vs. 6.5 months) in foster care until reunification\(^2\)
• Integrated Assessment (IA): Assessment and service delivery for youth entering foster care:
  • **Phase I:** Initial Assessment – Begins during investigation by Child Protection
  • **Phase II:** Integrated Assessment (IA) – Begins once a youth is taken into Temporary Custody and ends with the completion of the **IA CANS**, development of the family service plan, and culmination of the initial Family Meeting, within 40 days after Temporary Custody
  • **Phase III:** Ongoing Assessment – Throughout the life of the family’s involvement with DCFS
IA (Integrated Assessment) Timeline

- Day 15: Comprehensive Health Examination due - Healthworks sends report in 7 days to IA
  - All IA interviews complete

- Day 21:

- Day 30:
  - IA report drafted/CANS scored
  - Clinical screener meets

- Day 40:
  - IA report and Service Plan submitted to Juvenile Court

- Day 45:
  - IA report complete
  - Family meeting occurs

Weekly Supervision
- Biweekly In-Person Contact with Child
- Monthly In-Person Contact with Substitute Caregiver

Weekly In-Person Contact with Parent
- (and any Child who remains with Parent)
- Monthly Contact with Service Providers
Illinois CANS in the Illinois Child Welfare System

• Implementation since 2007

• Types
  • IA CANS (at entry)
  • Caseworker CANS (every 6 months)
  • CANS at residential treatment center (within 30 days of admission, every 90 days until discharge)
  • Child and Youth Investment Team CANS (triggered by placement disruption; no longer in use)

• Version evolution
  • Comprehensive CANS/CANS 1.0
  • CANS 2.0
  • IM-CANS
Predictive Analytics
Predictive Analytics

• Extracts information from large-scale data to identify data patterns and predict the likelihood of future outcomes

• Potential applications in the child welfare system:
  • Identify individuals “at risk” of an adverse event to inform prevention of the adverse event (e.g., psychiatric hospitalization, residential placement)
  • Identify risk factors to inform services and treatments tailored to the needs of the “at risk” individuals
  • Help child welfare administrators allocate limited resources (e.g., evidence-based/informed practices) to target populations (e.g., youth at risk of psychiatric hospitalization, residential placement)
  • Assist decision-making by providing additional information to caseworkers, supervisors, and administrators
Predictive Analytics

Empirically predict/estimate the likelihood/probability of an event/outcome of interest

- Prediction ≠ Causality
- Prediction ≠ Crystal ball
- Prediction ≠ Absolute truth
- Prediction ≠ Error free
Predictive Analytics: Methodological Approaches (Some)

- **Regression** (e.g., linear, time-to-event, Poisson)
  - Estimates relationship among selected variables
  - Can describe the strength (“weight”) of a predictor’s relationship with an outcome
  - “Best fit” line formula minimizes differences between “predicted” and “observed” outcomes

- **Machine Learning**
  - Searches for patterns in mass data
  - Modeled on artificial intelligence (i.e., “learning”)
    - Decision tree learning (e.g. random forest)
    - Deep learning (e.g. neural network)
  - Formula yields a probability of prediction

Both approaches yield algorithms for prediction
Evaluating a Predictive Analytic Model

- Error rate
  - True Positive
  - True Negative
  - False Negative
  - False Positive

<table>
<thead>
<tr>
<th>Predicted Outcome</th>
<th>Actual Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Yes</td>
<td>True Positive</td>
</tr>
<tr>
<td>No</td>
<td>False Negative</td>
</tr>
</tbody>
</table>

- Threshold
  - Turning continuous predicted “risk scores” into categorical prediction (e.g., yes/no)
Two Examples: Incorporating CANS into Predictive Analytic Models

Predicting **psychiatric hospitalization** in a child welfare system
- 3.1% of the U.S. child welfare population experiences psychiatric hospitalization, the 3rd most costly Medicaid-funded service
- Association with decreased placement stability and decreased likelihood of permanency

Predicting **residential placement** in a child welfare system
- 12.2% of the U.S. child welfare population are placed in group home or institution on the last day of the federal fiscal year
- Family First Prevention Services Act (FFPSA) (P. L. 115-123) and its Qualified Residential Treatment Programs (QRTPs) provisions
Predicting First Psychiatric Hospitalization at Entry to the Illinois Child Welfare System

- **Goal:** Estimate the risk of first psychiatric hospitalization among youth upon entering custody of DCFS in order to provide preventive interventions.

- **Cohort:** DCFS legal custody spells of youth who entered DCFS custody between 1/1/10 and 12/31/18 who had a CANS within 90 days of the legal custody spell (n=24,540).

- **Predictive Analytic Model:** Cox proportional-hazards regression predicting first psychiatric hospitalization.
Predicting First Psychiatric Hospitalization at Entry to the Illinois Child Welfare System

• **Fixed Predictors:** Gender, ethnicity, developmental disability status, DCFS region, year of entry to DCFS custody, number of prior DCFS legal custody spells, baseline CANS (average domain scores)

• **Time-Varying Predictors:** Age at beginning of each placement, most recent allegation type, number of prior placements, placement type, number of siblings in the same placement, and the interaction of number of siblings in the same placement by placement type

• **Outcome:** Psychiatric hospitalization as defined by DCFS living arrangement codes

• **Model Validation:** Using 200 bootstrap samples, examine model prediction accuracy using bias-corrected indices
## CANS Predictors (Average Domain Scores)

<table>
<thead>
<tr>
<th>CANS Domain</th>
<th>CANS Items</th>
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</thead>
<tbody>
<tr>
<td>Traumatic Stress Symptoms (5 Items)</td>
<td>Adjustment to Trauma</td>
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<tr>
<td></td>
<td>Re-experiencing</td>
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<tr>
<td></td>
<td>Avoidance</td>
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<td></td>
<td>Numbing</td>
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<td></td>
<td>Dissociation</td>
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</table>

<table>
<thead>
<tr>
<th>CANS Domain</th>
<th>CANS Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emotional/Behavioral Needs (13 Items)</td>
<td>Psychosis</td>
</tr>
<tr>
<td></td>
<td>Attention Deficit/Impulse Control</td>
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<tr>
<td></td>
<td>Depression</td>
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<tr>
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<td>Anxiety</td>
</tr>
<tr>
<td></td>
<td>Oppositional Behavior</td>
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<tr>
<td></td>
<td>Conduct</td>
</tr>
<tr>
<td></td>
<td>Substance Abuse</td>
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<tr>
<td></td>
<td>Attachment Difficulties</td>
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<tr>
<td></td>
<td>Eating Disturbances</td>
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<td>Affect Dysregulation</td>
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<td>Behavioral Regression</td>
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<tr>
<td></td>
<td>Somatization</td>
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<td>Anger Control</td>
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</table>
CANS Predictors (Average Domain Scores)

<table>
<thead>
<tr>
<th>CANS Domain</th>
<th>CANS Items</th>
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<td>Risk Behaviors (11 items)</td>
<td>Suicide Risk</td>
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<td>Self Mutilation</td>
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<tr>
<td></td>
<td>Other Self-Harm</td>
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<td></td>
<td>Danger to Others</td>
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<tr>
<td></td>
<td>Sexual Aggression</td>
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<tr>
<td></td>
<td>Runaway</td>
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<tr>
<td></td>
<td>Delinquency</td>
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<td></td>
<td>Judgment</td>
</tr>
<tr>
<td></td>
<td>Fire Setting</td>
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<tr>
<td></td>
<td>Social Behavior</td>
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<tr>
<td></td>
<td>Sexually Reactive Behaviors</td>
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<table>
<thead>
<tr>
<th>CANS Domain</th>
<th>CANS Items</th>
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<tbody>
<tr>
<td>Social Functional Behaviors (3 Items)</td>
<td>Social Functioning</td>
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<tr>
<td></td>
<td>School Behavior</td>
</tr>
<tr>
<td></td>
<td>Social Behavior</td>
</tr>
</tbody>
</table>
Descriptive Comparisons: 
Average Baseline CANS Domain Scores

- **Traumatic Stress Symptoms**
  - With First Psychiatric Hospitalization (n=2,699): 0.95
  - No Psychiatric Hospitalization (n=21,841): 0.50

- **Emotional/Behavioral Needs**
  - With First Psychiatric Hospitalization (n=2,699): 0.78
  - No Psychiatric Hospitalization (n=21,841): 0.27

- **Risk Behaviors**
  - With First Psychiatric Hospitalization (n=2,699): 0.55
  - No Psychiatric Hospitalization (n=21,841): 0.10

- **Social Functional Behaviors**
  - With First Psychiatric Hospitalization (n=2,699): 1.04
  - No Psychiatric Hospitalization (n=21,841): 0.31
Factors Associated with Decreased vs. Increased Risk of First Psychiatric Hospitalization
Psychiatric Hospitalization Risk within First 90 Days of Entry to DCFS Custody

- Low Risk (<1%)
- Medium Risk (1%-5%)
- High Risk (>5%)

% Observed
0%  10%  20%  30%

% Predicted
0.3%  2.3%  16.9%
# Model Accuracy

<table>
<thead>
<tr>
<th>Index</th>
<th>Original Cohort</th>
<th>Bootstrap Models Applied to Bootstrap Samples</th>
<th>Models Trained from Bootstrap Samples Applied to Original Cohort</th>
<th>Optimism/Bias Correction</th>
<th>Corrected Index</th>
<th>Number of Bootstrap Resample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Somers’ $D_{xy}$</td>
<td>0.7729</td>
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</table>
Predicting First Residential Placement at Entry to the Illinois Child Welfare System

• **Goal:** Estimate the risk of first residential placement among youth upon entering custody of DCFS in order to provide preventive interventions

• **Cohort:** DCFS legal custody spells of youth who entered DCFS custody between 1/1/10 and 12/31/18 who had a CANS within 90 days of the legal custody spell (n=24,540)

• **Predictive Analytic Model:** Cox proportional-hazards regression predicting first residential placement
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• **Time-Varying Predictors:** Age at beginning of each placement, most recent allegation type, number of prior placements, number of siblings in the same placement

• **Outcome:** Residential placement as defined by DCFS living arrangement codes

• **Model Validation:** Using 200 bootstrap samples, examine model prediction accuracy using bias-corrected indices
Descriptive Comparisons:
Average Baseline CANS Domain Scores

- **With First Residential Placement (n=2,723)**
- **No Residential Placement (n=21,817)**

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<thead>
<tr>
<th>Domain</th>
<th>With Placement</th>
<th>No Placement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traumatic Stress Symptoms</td>
<td>0.97</td>
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<tr>
<td>Emotional/Behavioral Needs</td>
<td>0.89</td>
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<tr>
<td>Risk Behaviors</td>
<td>0.72</td>
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<tr>
<td>Social Functional Behaviors</td>
<td>1.25</td>
<td>0.29</td>
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</tbody>
</table>
Factors Associated with Decreased vs. Increased Risk of First Residential Placement

- With sibling(s) in same placement: 0.10
- Most recent allegation: Infant substance exposure: 0.59
- Most recent allegation: Substantial risk of harm: 0.59
- Most recent allegation: Environmental neglect: 0.67
- Non-White and Non-Black: 0.70
- Most recent allegation: Lack of supervision: 0.71
- DCFS Central region: 0.76
- CANS: Traumatic Stress Symptoms: 0.80
- Most recent allegation: Physical abuse: 0.81
- Female: 0.83
- Year of entry: 2006-2011: 0.88
- Year of entry: 2000-2005: 0.88
- Age at beginning of each placement: 1.16
- CANS: Social Functioning Behaviors: 1.27
- CANS: Risk Behaviors: 2.18
- CANS: Emotional/Behavioral Needs: 2.57
Residential Placement Risk within First 90 Days of Entry to DCFS Custody
## Model Accuracy

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<td>0.8561</td>
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<td>0.0087</td>
<td>0.9913</td>
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</tbody>
</table>
Implications on Implementation and Practice

• Multiple baseline CANS domains were significantly associated with risk of psychiatric hospitalization and residential placement

• Leverage CANS by frontline caseworkers to make proactive recommendations for “preventive” services to deflect youth psychiatric hospitalization and residential placement
Implications on Implementation and Practice

• Embed predictive analytic models into child welfare system’s operation
  • Does the child welfare system have internal capacity (e.g., technical, technological) to maintain, refine, and apply predictive analytic models?

• How (e.g., dashboard), when (e.g., at case opening), and to whom (e.g., caseworker, supervisor) are the “risk scores” provided?

• How are the models used to support but not to replace decision-making (e.g., prioritize youth, service planning, case closing, team meetings)?
Questions and Discussion
References


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