Dynamic Simulation of Crime Perpetration and Reporting to Examine Community Intervention Strategies

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Health Education and Behavior
Project & Team Background

- **Objective:** Develop a computational agent-based model (ABM) to explore the impact of community-wide verses spatially focused crime reporting interventions to reduce community crime perpetrated by youth;

- Interdisciplinary team of individuals with backgrounds in community health, intervention development, translational research, computational modeling, and violence
Agent Based Modeling (ABM)

• A type of computational model for simulating actions and interactions of autonomous agents (individual and collective) to study their effects on the system as a whole.

• Simulate interactions of multiple agents in an attempt to re-create and predict complex phenomena (Niazi, 2011).
Community Crime and Public Health

• Violence is 2nd leading cause of death for youth ages 15-24: (CDC, 2011)
• Leading cause of death for African American youth
• Community interventions include encouraging citizens and victims to report crime
• However, approximately half of violent crimes go unreported

We are developing synthetic models to examine and evaluate potential community crime intervention strategies
Homicide Rates 2000-2012
(United States, Allegheny County, and City of Pittsburgh)

DHS, 2011
Pittsburgh Context: Aggravated Assaults with Firearm Clusters with the City of Pittsburgh, 1997-2007
Why use ABM?

• To understand the complex social systems and dynamics in health (e.g., immunization and school closure policy);

• Models can adopt an integrated ecological systems approach – the models are DYNAMIC;

• Models can simulate interventions to provide insights about relative effectiveness;

• To make informed programmatic and policy decisions;

• A forum for integrating diverse expertise, thought principles of partnered research.
Graffiti serves as a proxy for community crime
Community input to research and interventions

Community Crime Modeling (Winer and Ray, 2000)
Background:

- ABM capture effects of individual experiences and decisions
  - change in attitude of witnesses or victims
  - change in attitude of offenders due to punishment (or not)
- **Collective efficacy** refers to the effectiveness of informal mechanisms by which residents achieve public order  (Sampson et al., *Science* 1997)
  - A key mechanism influencing interpersonal violence in a neighborhood
  - Contrasts with formally or externally induced actions
    - e.g. police intervention, administrative programs
Research Questions

**Q1:** How do agents operate in a dynamic environment?

**Q2:** Can we capture other theoretical constructs in a spatially explicit model (i.e., dynamics of neighborhood contagion, collective efficacy)?

**Q3:** Can we develop metrics to compare potential/proposed interventions?
Agents

• **Adults**
  – do not commit offenses
  – may witness a nearby incident
  – may report a witnessed incident

• **Juveniles**
  – may commit an offense
  – if reported, may receive punishment
    • assumed to reduce likelihood to offend in future
Daily Time Step of Simulation

1. Each juvenile moves a small distance
   – attracted toward areas of high opportunity
2. Each juvenile decides whether to commit an offense
   – based on the individual's current perceived risk and reward
3. Each adult probabilistically witnesses any nearby offense
   – based on the individual's current witnessing probability
4. Witnesses decide whether to report each offense
   – based on the individual's current reporting probability
5. If an offender is reported, he/she may received punishment with a global probability of punishment
6. If an offender is punished, increase perceived risk
7. If an offender is not punished, decrease perceived risk
Calibrating the Offenders

Pathways to Desistance Study (Shubert and Mulvey, 2011)

• Longitudinal survey of N = 1,354 active juvenile offenders over a three-year period

• Collected self-reported frequency of offenses, perceived rewards, perceived risk, at 6 month intervals

• Analysis explored differences in risk perception based on prior offending experience
  – Did perceptions shift as the result of arrest?

• Theory of Reasoned Action (Ajzen, 1980):
  – if perceived reward > perceived risk, then take action
Risk, Reward Perception by Offender

**Observations** (Shubert and Mulvey, 2011)

- The most frequent offenders perceived significantly less risk and more reward from crime than those with medium frequency of offenses.
- Individuals **decrease the level of perceived risk** when offending is undetected or avoids punishment.
- Individuals tend to **increase the level of perceived risk** when they are arrested.
- As individuals age, **perceived reward appears to decrease for all levels of offender frequency**.
Calibrated Model

Shubert and Mulvey, 2011

Simulation Data
The ABM: Visualization of Patch Incidence Levels

Guided by initial crime and reporting parameters, behavior characteristics of the agents (i.e., juveniles and adults), model generates areas of high crime for piloting interventions

- Pink-colored irregular regions are associated with high numbers of recent incidents.
- Offenders follow local gradients of "high opportunity", leading to clustering offenses.
- Activated adults are represented by squares, and juvenile offenders who being reported by activated adults are indicated by circles.
Movie example..

- https://www.dropbox.com/s/zwltw5ht4092h2r/local_10_7943.mov
A close-up view of agents…

(1) juveniles who have not offended on the current time step are purple;
(2) offenders who have not been reported are red;
(3) offenders who have been reported and will be punished are orange;
(4) adults who witness an offense and report it are green;
(5) adults that have not witnessed an offense on the current time step are blue.
Reduction in Offenses

• Spatially focused interventions reduce offenses slightly more than community-wide intervention if fewer than about 2.5% of adults are activated,

• Community-wide interventions provide a larger reduction in offenses for intervention that activate more than 3% of the adults in the community.

Percent Activated

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Cost-Effectiveness

Percent Activated

• Spatially focused interventions reduce offenses more cost-effectively than community-wide intervention if fewer than about 2.5% of adults are activated;
• community-wide interventions provide a relatively constant reduction in offenses for intervention that activate up to 10% of adults
Results and Next Steps

• spatially focused intervention yielded localized reductions in crimes, consistently defer crime to nearby community settings;

• Community-wide interventions produced consistent, community-wide and sustained crime offense reductions;

• Model now integrates empirical data and community demographics…one step further to community/policy application;

• Results are being shared with an expanding network of law enforcement, organizational and academic partners to inform the ABM and action.
Limitations and Lessons Learned

• Early stage model (ie., toy model)
• Importance of an interdisciplinary team, including community partners with hands-on experience
• Importance of developing a common language
• ABM allows for the exploration of complex problems and associated interventions & provides a visual tool for displaying the impact of interventions
Thank you!

• Questions?

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Motive (Where Known) in City of Pittsburgh Homicide Cases, 2000-2012 (DHS, 2011)
Community Crime
toy model evolution
(CAN WE INSERT A MOVIE TO SHOW IF THERE IS TIME??)...