A Systems Modeling Approach for Improving Oral Health Outcomes of Older Adults

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A large number of US residents will soon be entering retirement age.

Source: UN World Population Prospects 2008

Source: The 2000 US Census
Context

• With this demographic shift, healthcare services designed for the nation’s seniors must be reevaluated.

• Changes:
  – Insurance
  – Social networks
  – Physical and cognitive abilities

• We are examining one particular facet of this broad research agenda:
  – Oral health
Why oral health?

- The mouth is the gateway of the body.
  - Early warning system for diseases (HIV/AIDS, Immune system problems, general infections, stress)
  - Signals nutritional deficiencies
  - Associated with diabetes, CVD, stroke
- Generally understudied
  - Potential to be a novel way to study the body as an integrated system because of the mouth’s accessibility
ElderSmile

- **ElderSmile** (Lamster and Northridge, 2008)
  - Program sponsored by Columbia’s College of Dental Medicine
  - Goals:
    - Clinical care
    - Education
    - Research
    - Policy
  - Aims to alleviate burden of oral diseases on older adults
  - Study conducted in Manhattan
    - Many participants reside in Upper Manhattan
This table showcasing some of the study’s findings hints at the disparities present in dental care:

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean DMFT (SE)</th>
<th>p-value</th>
<th>Mean DT (SE)</th>
<th>p-value</th>
<th>Mean MT (SE)</th>
<th>p-value</th>
<th>Mean FT (SE)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in years</td>
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</tr>
<tr>
<td>65-74</td>
<td>20.6 (0.3)</td>
<td>0.19</td>
<td>0.9 (0.1)</td>
<td>0.66</td>
<td>14.2 (0.5)</td>
<td>0.05</td>
<td>5.5 (0.3)</td>
<td>0.04</td>
</tr>
<tr>
<td>75+</td>
<td>21.2 (0.3)</td>
<td></td>
<td>1.0 (0.1)</td>
<td></td>
<td>15.6 (0.5)</td>
<td></td>
<td>4.7 (0.3)</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Men</td>
<td>20.5 (0.4)</td>
<td>0.14</td>
<td>1.4 (0.2)</td>
<td>&lt;0.01</td>
<td>13.9 (0.6)</td>
<td>0.04</td>
<td>5.2 (0.4)</td>
<td>0.66</td>
</tr>
<tr>
<td>Women</td>
<td>21.2 (0.3)</td>
<td></td>
<td>0.7 (0.1)</td>
<td></td>
<td>15.4 (0.5)</td>
<td></td>
<td>5.0 (0.3)</td>
<td></td>
</tr>
<tr>
<td>Race/ ethnicity</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Non-Hispanic White</td>
<td>20.4 (0.5)</td>
<td>0.09</td>
<td>1.2 (0.3)</td>
<td>0.13</td>
<td>8.9 (0.9)</td>
<td>&lt;0.01</td>
<td>10.4 (0.7)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Non-Hispanic Black</td>
<td>21.2 (0.4)</td>
<td></td>
<td>1.0 (0.1)</td>
<td></td>
<td>16.4 (0.6)</td>
<td></td>
<td>3.9 (0.3)</td>
<td></td>
</tr>
<tr>
<td>Non-Hispanic Other</td>
<td>18.4 (1.2)</td>
<td></td>
<td>1.3 (0.4)</td>
<td></td>
<td>10.4 (1.5)</td>
<td></td>
<td>6.8 (0.8)</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>21.1 (0.4)</td>
<td></td>
<td>0.7 (0.1)</td>
<td></td>
<td>16.1 (0.6)</td>
<td></td>
<td>4.2 (0.3)</td>
<td></td>
</tr>
<tr>
<td>Education level</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Less than high school</td>
<td>21.7 (0.5)</td>
<td>0.02</td>
<td>1.0 (0.2)</td>
<td>0.89</td>
<td>17.4 (0.7)</td>
<td>&lt;0.01</td>
<td>3.4 (0.3)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>High school</td>
<td>21.0 (0.4)</td>
<td></td>
<td>0.9 (0.1)</td>
<td></td>
<td>15.5 (0.6)</td>
<td></td>
<td>4.6 (0.3)</td>
<td></td>
</tr>
<tr>
<td>More than high school</td>
<td>20.0 (0.4)</td>
<td></td>
<td>0.9 (0.1)</td>
<td></td>
<td>11.4 (0.7)</td>
<td></td>
<td>7.7 (0.4)</td>
<td></td>
</tr>
<tr>
<td>Smoking history</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current smoker</td>
<td>23.0 (0.7)</td>
<td>&lt;0.01</td>
<td>1.8 (0.5)</td>
<td>&lt;0.01</td>
<td>18.2 (1.2)</td>
<td>&lt;0.01</td>
<td>3.0 (0.6)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Former smoker</td>
<td>22.0 (0.4)</td>
<td></td>
<td>1.0 (0.2)</td>
<td></td>
<td>15.8 (0.7)</td>
<td></td>
<td>5.2 (0.5)</td>
<td></td>
</tr>
<tr>
<td>Never smoked</td>
<td>20.0 (0.3)</td>
<td></td>
<td>0.7 (0.1)</td>
<td></td>
<td>13.5 (0.5)</td>
<td></td>
<td>5.7 (0.3)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>20.9 (0.2)</td>
<td></td>
<td>0.9 (0.1)</td>
<td></td>
<td>14.9 (0.4)</td>
<td></td>
<td>5.1 (0.2)</td>
<td></td>
</tr>
</tbody>
</table>
Present Work

• Aims:
  - build a dynamic model of factors affecting tooth retention in older adults
    • interest in improving minority residents’ oral health
  - evaluate the performance of the simulations to project the impact of proposed interventions

• Survey data from ElderSmile allows us to initialize agents to capture system dynamics

• Start with: What factors influence the oral health of older adults?
  - Causal map done with experts in dentistry, public health
While not exhaustive, Figure 5 provides potential variables for inclusion in our SD model arranged by scale.

<table>
<thead>
<tr>
<th>FUNDAMENTAL (societal/macro scale)</th>
<th>INTERMEDIATE (community/meso scale)</th>
<th>PROXIMATE (interpersonal/micro scale)</th>
<th>HEALTH OUTCOMES (individual and population scales)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural environment</td>
<td>Built environment</td>
<td>Stressors/Buffers</td>
<td>Oral health outcomes</td>
</tr>
<tr>
<td>• topography</td>
<td>• land use</td>
<td>• neighborhood and housing conditions</td>
<td>• dental caries</td>
</tr>
<tr>
<td>• climate</td>
<td>• transportation systems</td>
<td>• violent crime and safety</td>
<td>• tooth loss</td>
</tr>
<tr>
<td>• water supply (fluoridation)</td>
<td>• services (shopping, banking, health and dental care)</td>
<td>• police response</td>
<td>• periodontal diseases</td>
</tr>
<tr>
<td>• air quality</td>
<td>• public resources (parks, museums)</td>
<td>• financial insecurity</td>
<td>• oral cancer</td>
</tr>
<tr>
<td></td>
<td>• buildings (housing, senior centers)</td>
<td>• environmental toxins (lead, particulates)</td>
<td>• pharyngeal cancer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• unfair treatment (stigma, prejudice)</td>
<td>• oral mucosal lesions</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• candidiasis</td>
</tr>
<tr>
<td>Macrosocial factors</td>
<td>Social context</td>
<td>Health behaviors</td>
<td>Related health outcomes</td>
</tr>
<tr>
<td>• historical conditions</td>
<td>• cultural identity</td>
<td>• oral health screenings</td>
<td>• movement disorders</td>
</tr>
<tr>
<td>• political and economic orders</td>
<td>• community investment (economic development, maintenance, police and social services)</td>
<td>• oral hygiene activities (brushing, flossing)</td>
<td>• cognitive impairment</td>
</tr>
<tr>
<td>• human rights doctrines</td>
<td>• policies (public, fiscal, environmental, health and dental coverage)</td>
<td>• physical activity</td>
<td>• musculoskeletal conditions</td>
</tr>
<tr>
<td>• social and cultural institutions</td>
<td>• enforcement of ordinances (public, environmental)</td>
<td>• dietary practices (fruit and vegetable intake)</td>
<td>• cardiovascular diseases</td>
</tr>
<tr>
<td>• ideologies (ageism, racism)</td>
<td>• distribution of material wealth</td>
<td>• substance use (tobacco, alcohol, prescription medications)</td>
<td>• cerebrovascular diseases</td>
</tr>
<tr>
<td></td>
<td>• distribution of educational attainment</td>
<td></td>
<td>• diabetes mellitus</td>
</tr>
<tr>
<td></td>
<td>• distribution of political influence</td>
<td></td>
<td>• neurological disorders</td>
</tr>
</tbody>
</table>

Figure 5: Ecological Model of Social Determinants of Oral Health for Seniors. This ecological model for thinking about pathways whereby social determinants at various scales (societal, community, and interpersonal) influence oral health and well-being for both individuals and populations of seniors is adapted from a conceptual model titled, “Social Determinants of Health and Environmental Health Promotion” that first appeared in Northridge, 2003a.
Causal Map

- Dental health
  - Oral hygiene activity
  - Oral health promotion
  - Social engagement
  - Social support
  - Transportation
  - Community access
  - Practitioner knowledge
  - Preventive screenings
  - Treatment

- Chronic illness
  - Age

- Range of food choice
- Ability to chew

- Healthy food choice
- Cognitive function

- Appetite
- Nutrition
- Metabolism
- Physical ability
Present Work

• The primary focus of this prototype model is to explore how older adults seek and receive oral healthcare.

• Geocode residences of ElderSmile participants
  • Initialize residents with survey data
    – # and condition of teeth
    – Gender
    – Race
    – Smoker
    – Etc…
Multi-Scalar Approach

• We use AnyLogic software
  – Allows for easy integration of ABM, SD, and GIS
  – Encapsulation is employed to capture different scales
Knowledge Diffusion

• Spatial Constraints
  – The use of geographic data allows us to consider the influence of space and mobility
    • Is it difficult to reach a dentist’s office?
    • What role does spatial isolation from peers play?
  – Presently, the proximity network is the only implementation
  – In progress:
    • a distance decay function that affects whether and where a resident will seek dental care
    • a more nuanced social network structure
    • transportation considerations
ElderSmile
Treatment & Prevention Centers
- **Green Dot**: Treatment Centers
- **Red Dot**: Prevention Centers
- **Gray Shade**: Streets

Isabella
Fort Washington ACN
The Imma Adair Medical/Dental Center
Knowledge Diffusion

• Presently, the model is essentially a diffusion model.
  – Social network is a simulated small world-type network

Statechart from Anylogic
Knowledge Diffusion

- Preliminary results
  - The slope and final percentage with a dentist shifts based on parameters
What about the teeth?

- However, the addition of tooth level data adds to the model’s complexity.
What about the teeth?

- We have individual level data, with information on every tooth.
- However, we have not yet parameterized the dynamics of tooth decay.
What about the teeth?
Future Work

• Seeking input
  – Analogous public health issues?
  – Emphasis on social dynamics and disparity
    • How does race, gender influence likelihood of participation?
    • Network structure?
  – Research design for an expanded study that includes Buffalo & NYC
  – Different policy experiments?
    • Frequency (delays)
    • Types of coverage
    • Resource scenarios

• Contact: mjwidene@buffalo.edu
Acknowledgments

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