Knowledge Laboratory of the Early life Course

Barry Milne and COMPASS team

COMPASS Seminar Series
4 August 2016
Outline

- What is microsimulation?
  - A simple example

- MEL-C
  - Key features, Results, Insights & observations

- Knowledge Lab of the Early Life Course
  - Aims
  - 3 models: **Obesity, Education** & Mental health
  - Web deployment using Shiny
What is Microsimulation?

- Simulates plausible data for micro-level units (i.e., people, businesses, ...)

- It (typically) uses empirical data as a basis to simulate real or alternative worlds, and their futures

- It enables experimentation in a virtual lab
Microsimulation: A virtual world

- Start with a real (or realistic synthetic) sample of people
- Apply statistically-derived rules to reproduce patterns via a stochastic process
- We have created a virtual world (our simulation model)
- Predict what might happen if conditions were to change (i.e., by altering parameters)
A simple worked example (made up)

• Suppose every child born has the same probability of attending early childhood education (ECE)
  • $p = 0.50 \leftarrow \text{transition probability}$

• And that those who do attend have the probability of leaving school with qualifications (SCQUAL):
  • $p = 0.80 \leftarrow \text{transition probability}$

• And that those who don’t attend have the probability of leaving school with qualifications:
  • $p = 0.50 \leftarrow \text{transition probability}$
A simple worked example

- Simulation is a **stochastic** process, so you get different results each time
  - On each simulation run, different units may be simulated as
    (i) attended ECE
    (ii) left school with qualifications

Imagine 2 individuals

<table>
<thead>
<tr>
<th></th>
<th>Run1</th>
<th>Run2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abby</td>
<td>p(ECE) 0.5</td>
<td>p(ECE) 0.5</td>
</tr>
<tr>
<td></td>
<td>ECE? Yes</td>
<td>ECE? No</td>
</tr>
<tr>
<td></td>
<td>p(ScQ) 0.8</td>
<td>p(ScQ) 0.5</td>
</tr>
<tr>
<td></td>
<td>ScQ? Yes</td>
<td>ScQ? No</td>
</tr>
<tr>
<td>Brian</td>
<td>p(ECE) 0.5</td>
<td>p(ECE) 0.5</td>
</tr>
<tr>
<td></td>
<td>ECE? No</td>
<td>ECE? No</td>
</tr>
<tr>
<td></td>
<td>p(ScQ) 0.5</td>
<td>p(ScQ) 0.5</td>
</tr>
<tr>
<td></td>
<td>ScQ? No</td>
<td>ScQ? Yes</td>
</tr>
</tbody>
</table>
A simple worked example

- Simulation is a **stochastic** process, so you get different results each time
  - On each simulation run, different units may be simulated as
    (i) attended ECE
    (ii) left school with qualifications

- Best to take a number of runs and average...

- For 5 runs & 20 units
  - Av=10.2/20 attended ECE
  - Av=13.2/20 left school with qualifications
A simple worked example

• Suppose an intervention is suspected to increase the probability of children attending ECE to
  • \( p = 0.80 \)

• But the probability of leaving school with qualifications remains the same
  (\( p=0.80 \) for attenders; \( p=0.50 \) for non-attenders)

• What would happen??
A simple worked example

- For 5 runs & 20 units,
- $\text{Av}=16/20$ attended ECE
- $\text{Av}=14.8/20$ left school with qualifications, an increase from $13.2/20$ (8% increase)

- A very simple model for which simulation probably not needed… …But if lots of factors affect ECE attendance, and its association with school qualifications (through potentially multiple pathways)

Microsimulation can capture this in one model, and allows counterfactuals to be tested
A real simulation model: Modelling the Early Life-course (MEL-C)

1. Goals … what did we do?
   - Developed a software application as a decision-support tool for policy-making

2. Rationale … why did we do it?
   - To improve policymakers’ ability to respond to issues concerning children and young people

3. Means … how did we do it?
   - By building a computer simulation model (n=5000) with data from existing longitudinal studies to quantify the underlying determinants of progress in the early life course
MEL-C - Conceptual framework

**Structural level**

**Child characteristics**
- (age)
- gender
- ethnicity

**Parental characteristics**
- age at birth of child
- ethnicity
- education level

**Socio-economic position**
- SES at birth of child
- (single-parent status at birth)

**Intermediate level**

**Family/household characteristics**
- e.g. single-parent status, number of children, household size

**Employment**
- e.g. parental employment, welfare dependence

**Material circumstances**
- e.g. housing: accommodation type, owned-rented, bedrooms number

**Psychosocial factors**
- e.g. family functioning: change of parents, change of residence

**Behavioural factors**
- e.g. parental smoking

**Other factors**
- e.g. perinatal factors

**Outcome**

**Health service use**
- e.g. GP visits, hospital admissions, hospital outpatient attendances

**Education**
- e.g. reading ability

**Social/Justice**
- e.g. Conduct disorder

**Other factors**
- e.g. perinatal factors
MEL-C - Insights

- Able to model early life-course very well

- Changing factors in children’s lives often had weak effects on child outcomes
  - Is that just the reality of policy impact?
  - Need to change multiple factors?
  - Most important factors sometime not the most policy amenable (maternal education)

- Policy relevance increased by increasing range of outcomes & factors
Astute observation 1
- There are many well-established estimates for factors that impact the lives of children, but these exist in isolation; micro-simulation offers a way to bring these together
  - John Lynch, Professor of Public Health, University of Adelaide

Astute observation 2
- ‘Best’ estimates are thought to be derived from systematic reviews/meta analyses, but it is difficult to test their validity.
  - David Gough, Professor of Evidence Informed Policy and Practice, Institute of Education
Knowledge Laboratory
- Aims

- Identify key determinants of child and adolescent outcomes

- Integrate estimates from systematic reviews/meta analyses into working model of early life course
  - Developed from MEL-C (n=5000); extended in breadth (more determinants and outcomes), and length (to age 21)

- Use as knowledge laboratory
  - Test the validity of ‘best’ estimates
  - Test policy scenarios using validated model
End user engagement

Important role of policy reference “End User” group
- Engage key people from government agencies
- Use their expertise to get better model & policy-relevant scenarios

Seven agencies involved
- Health
- Education
- Social Development
- Justice
- Te Puni Kōkiri
- Children’s Commission
- SuPERU
Focus on three outcomes

- Obesity
- Education
- Mental Health

For each outcome

- Determine conceptual framework
- Get NZ prevalences and inter-relations for each predictor in the conceptual framework
- Get meta-analytic estimates for each path in the conceptual framework
  - Harder than you might think…
  - Quality assessments undertaken
Literature comparing effect sizes for Māori vs non-Māori

- Getting meta-analytic estimates from literature all very well
  - …But will they accurately represent estimates for Māori? (or Pacific, etc…)

- Searched the literature for papers looking at health, education, psychosocial functioning for Māori youth, and found..
  - Most in health area, e.g. smoking (n=49), asthma (n=30)

- Few papers looked at risk factors (n=68; 10%)
  - Largely found in the smoking literature (n=14; 20%)
  - Few of these assessed if magnitude of risk factor effect different Māori vs non-Māori, so a real gap in the literature
Obesity - Conceptual framework

- Maternal smoking
- Maternal BMI
- Caesarean
- Preterm birth
- Birth weight
- Early solid foods
- Breast feeding
- Rapid weight gain
- Parental BMI
- Quality of sleep
- Energy balance
- Overweight/Obesity

SES

Prenatal
Birth
Postnatal
Infancy
Childhood/Adolescence
Base simulation
Obesity Scenario: 1. Maternal Overweight

- Maternal Overweight
  - Base: 43%
  - Scenario: Decrease to 21%

|                | Child Overweight % reduction  
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(av over ages 6-12)</td>
</tr>
<tr>
<td>All</td>
<td>4.4%</td>
</tr>
<tr>
<td></td>
<td>(2.5% - 6.4%)</td>
</tr>
<tr>
<td>Māori</td>
<td>6.7%</td>
</tr>
<tr>
<td></td>
<td>(2.9% - 10.1%)</td>
</tr>
<tr>
<td>Pasifika</td>
<td>6.1%</td>
</tr>
<tr>
<td></td>
<td>(-0.5% - 12.3%)</td>
</tr>
<tr>
<td>Low SES</td>
<td>5.7%</td>
</tr>
<tr>
<td></td>
<td>(2.5% - 8.1%)</td>
</tr>
</tbody>
</table>
Obesity Scenario:
2. Breakfast consumption

Breakfast consumption
- Base: 81%
- Scenario: Increase to 100%

<table>
<thead>
<tr>
<th></th>
<th>Child Overweight % reduction (av over ages 5-21)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>2.4%</td>
</tr>
<tr>
<td></td>
<td>(0.3% - 4.3%)</td>
</tr>
<tr>
<td>Māori</td>
<td>4.0%</td>
</tr>
<tr>
<td></td>
<td>(0.1% - 7.8%)</td>
</tr>
<tr>
<td>Pasifika</td>
<td>3.0%</td>
</tr>
<tr>
<td></td>
<td>(-3.6% - 9.6%)</td>
</tr>
<tr>
<td>Low SES</td>
<td>3.5%</td>
</tr>
<tr>
<td></td>
<td>(0.1% - 6.8%)</td>
</tr>
</tbody>
</table>
Obesity model - Summary

- Modest effects of maternal overweight and breakfast consumption

- Effect of risk factors on population obesity determined by
  - Size of effect of risk factors
  - Prevalence of risk factor in population
  - ...as such, often small population effects, though bigger effects for the group that has been changed
Education - Conceptual framework

- Prenatal
- Birth
- Infancy
- Childhood
- Adolescence
- Young adulthood

Socioeconomic Status of parents

- Behavioural disability
- Aspirations, expectations

In-utero environment
- Gestational age
- Speech/language/hearing problems

Sex

Breast feeding

Early Cognitive Ability

Cognitive ability

Exam performance

Deprivation

ECE

Deviant behaviour

NEET
School and region effects

- To allow school interventions to be modelled
  - Education, but also Obesity and mental health
- And to allow for school- and/or teacher and/or peer-level effects

- Nest children within schools in the simulation
  - More realistic simulation as can account for dependence in data
  - Child who attend same school more similar

- One (easiest?) way to do this:
  - Assign children to regions (deterministically)
  - Assign children to schools within regions (stochastically)
School and region effects

- **5000 Children**
- **16 Regions**
- **100 Schools (from 479)**
  - 69 Secondary, 31 Composite
  - 79 Co-ed, 12 Girls, 9 Boys
  - 7 Kura Kaupapa
  - 3 Designated Character
Education Scenario: 1. Breastfeeding

Breastfeeding
- Base: 35.7% never breastfeed, 23.1% breastfed >6 months
- Scenario: Decrease never breastfed to 18%; Increase breastfed >6 months to 40%

<table>
<thead>
<tr>
<th>Cognitive Development (IQ)</th>
<th>NCEA 2 Attainment (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base</td>
</tr>
<tr>
<td>All</td>
<td>99.9</td>
</tr>
<tr>
<td>Māori</td>
<td>99.4</td>
</tr>
<tr>
<td>Pasifika</td>
<td>99.9</td>
</tr>
<tr>
<td>Low SES</td>
<td>99.7</td>
</tr>
</tbody>
</table>
Education Scenario: 2. Otitis media

- Otitis media
  - Base: 40% of children, at least episode age <5 years
  - Scenario: Reduce to 20%

<table>
<thead>
<tr>
<th></th>
<th>Cognitive Development (IQ)</th>
<th>NCEA 2 Attainment (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base</td>
<td>Scen</td>
</tr>
<tr>
<td>All</td>
<td>99.9</td>
<td>100.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Māori</td>
<td>99.4</td>
<td>100.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pasifika</td>
<td>99.9</td>
<td>100.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low SES</td>
<td>99.7</td>
<td>100.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Education Scenario: 3. Early Childhood Education (ECE)

- ECE Enrolment
  - Not enrolled 95.9%; Enrolled 4.1%

- What if the small number of children not receiving ECE ALL received it?

Setting the Scenario

<table>
<thead>
<tr>
<th>Variable Adjustment</th>
<th>Base value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td>Early Childhood Education</td>
</tr>
<tr>
<td>No (%)</td>
<td>0.00</td>
</tr>
<tr>
<td>Yes (%)</td>
<td>1.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Early Childhood Education</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
</tr>
<tr>
<td>Yes</td>
</tr>
</tbody>
</table>
Education Scenario:
3. Early Childhood Education (ECE)

- ECE Enrolment
  - Not enrolled 95.9%; Enrolled 4.1%

- What if the small number of children not receiving ECE ALL received it?

<table>
<thead>
<tr>
<th></th>
<th>NCEA 2 Attainment (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base</td>
</tr>
<tr>
<td>All</td>
<td>60.1</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Education model
- Summary

- Small effects overall

- Attending early childhood education will have a positive impact on later school achievement
Mental health - Conceptual framework

- Prenatal/Birth
  - Parental depression
  - Parental substance abuse
- Infancy
  - Gender
  - Parental attachment/warmth
- Childhood
  - Maltreatment
  - ADHD
- Adolescence
  - Stressful life events/adversity
  - Peer relations
  - School attainment
  - Smoking
  - Substance Abuse (Alcohol/Drug)
- Young adulthood
  - Obesity
  - Depression

Factors influencing mental health across different life stages:
- Socioeconomic Status of parents
- Stressful life events/adversity
Knowledge Lab is a microsimulation model focusing on three outcomes: Obesity, Education, and Mental Health

- Transitions in the model derived from meta-analytic estimates

- It can be used to test scenarios/counterfactuals
  - May be policy amenable; may not be

- Will be web-deployed (end 2016) using SHINY
  - Sneak peak coming up!
Developing a knowledge laboratory of the early life-course using systematic reviews and meta analyses

This is a three-year project funded by the Ministry of Business, Innovation and Employment through its health and society fund in 2013.

We will identify key determinants of child and adolescent outcomes, and will integrate estimates from systematic reviews and meta-analyses for these determinants into a working model of the early life-course (developed from an existing model we have created). We will use the working model as a "knowledge laboratory" to (i) test the validity of the underlying behavioural equations and specific knowledge sources (meta-analyses, systematic reviews); and (ii) test policy scenarios by carrying out experiments on the 'virtual cohort' created by the working model.

This research will involve the development of a micro-simulation model and associated computer software that allows users (policy makers, planners, analysts) to easily programme simulations and view the results. The end product will be an expert decision-support tool that will be available to the public policy community.

The research plan involves (i) identifying published systematic reviews and meta analyses relating to key outcomes for children and adolescents (to age 18); (ii) integrating estimates from these studies into, and thus enhancing, an existing micro-simulation model of the early life-course; (iii) validating the enhanced model, and thus published estimates, by comparing simulated results to published New Zealand benchmarks; and (iv) using the validated enhanced model to test the impact of various policies on key child and adolescent outcomes.

In using these best estimates to develop a micro-simulation model with which policy scenarios can be tested, our proposal will benefit NZ families/whanau by determining the policies that have the greatest impact on the lives of New Zealand children. Moreover, we will be uniquely placed to assess the impact of distinctive Maori programmes, such as Kohanga reo and Whānau Ora.
Demonstration - Table Builder
Demonstration - Table Builder

<table>
<thead>
<tr>
<th>Variable</th>
<th>Overweight in childhood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select Summary Measure</td>
<td>Percentage</td>
</tr>
<tr>
<td>Select a level to compare</td>
<td>Overweight</td>
</tr>
<tr>
<td>Select ByGroup</td>
<td>None</td>
</tr>
<tr>
<td>Select Subgroup for subgroup formula</td>
<td>None</td>
</tr>
<tr>
<td>Operators (And/Or/Complete/Reset)</td>
<td>Please select an operators below</td>
</tr>
<tr>
<td>Subgroup formula</td>
<td></td>
</tr>
<tr>
<td>Confidence Interval</td>
<td></td>
</tr>
<tr>
<td>Show</td>
<td></td>
</tr>
<tr>
<td>Download Table</td>
<td></td>
</tr>
<tr>
<td>Download Plot</td>
<td></td>
</tr>
</tbody>
</table>
Demonstration - Line graph
Demonstration - Line graph

Burt reading score

Mean

Year

8 9 10 11 12 13

80

70

60

50
Demonstration - Table Builder (subgroup)
Demonstration
- Table Builder (subgroup)

<table>
<thead>
<tr>
<th>Year</th>
<th>No_Mean</th>
<th>Overweight_Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>72.28</td>
<td>28.72</td>
</tr>
<tr>
<td>3</td>
<td>70.26</td>
<td>29.74</td>
</tr>
<tr>
<td>4</td>
<td>70.24</td>
<td>29.76</td>
</tr>
<tr>
<td>5</td>
<td>69.7</td>
<td>30.3</td>
</tr>
<tr>
<td>6</td>
<td>69.82</td>
<td>30.18</td>
</tr>
<tr>
<td>7</td>
<td>69.91</td>
<td>30.99</td>
</tr>
<tr>
<td>8</td>
<td>69.05</td>
<td>30.95</td>
</tr>
<tr>
<td>9</td>
<td>68.85</td>
<td>31.15</td>
</tr>
<tr>
<td>10</td>
<td>67.45</td>
<td>32.75</td>
</tr>
<tr>
<td>11</td>
<td>65.94</td>
<td>33.55</td>
</tr>
<tr>
<td>12</td>
<td>64.04</td>
<td>36.06</td>
</tr>
<tr>
<td>13</td>
<td>63.81</td>
<td>35.96</td>
</tr>
<tr>
<td>14</td>
<td>63</td>
<td>37.19</td>
</tr>
<tr>
<td>15</td>
<td>61.04</td>
<td>37</td>
</tr>
<tr>
<td>16</td>
<td>60.61</td>
<td>38.96</td>
</tr>
<tr>
<td>17</td>
<td>59.61</td>
<td>40.39</td>
</tr>
<tr>
<td>18</td>
<td>58.45</td>
<td>41.55</td>
</tr>
<tr>
<td>19</td>
<td>58.87</td>
<td>43.13</td>
</tr>
<tr>
<td>20</td>
<td>54.64</td>
<td>45.16</td>
</tr>
<tr>
<td>21</td>
<td>54.49</td>
<td>45.51</td>
</tr>
</tbody>
</table>
Demonstration
- Scenario builder
Demonstration - Naming Scenario

- Testing the effect of increasing breakfast consumption on obesity
Demonstration
- Selecting vars to change
Demonstration
Demonstration - ECE scenario

- Testing the effect of increasing ECE on school qualifications
But… School qualifications do change from 62% to 70% among those who previously had not attended ECE
Demonstration - Saving projects
Demonstration
- Uploading projects
THANKS!!

Thanks to

- Nichola Shackleton, Kevin Chang, Jessica McLay, Martin von Randow, Roy Lay-Yee, Pater Davis, Oliver Mannion, Janet Pearson

- All members of end user group since 2011 (MELC)
  - MOH: Martin Tobias, Pat Tuohy, Jackie Fawcett
  - MOE: Ann Armstrong, Lynne Whitney, Barclay Anstiss, Jasmine Ludwig, Roger Clark
  - MSD: Evan Thompson, Christina Connolly, many others
  - MOJ: Robert Lynn, Maragaret McArthur
  - TPK: Nathaniel Pihama
  - OCC: Kathleen Logan, Donna Provoost
  - SuPERU: Jeremy Robertson, Alex Collier
Quality Assessment

- Did they test for publication bias?
- Did they adjust estimates for publication bias?
- Did they run sensitivity analyses?
- Did they undertake moderator analysis (did effect sizes differ by characteristics of sample)?
- Did they assess quality of included studies?
- Were estimates based on high quality studies, or cross-sectional studies only?