Causal diagrams for evaluation of public health interventions

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Transport-related health problems

Distribution of vehicle emissions → Safe walking & cycling → Traffic volume → Traffic speed

Air pollution → Physical activity → Community severance → Access → Noise → Collisions: number, severity

Respiratory morbidity & mortality → Cardiovascular morbidity & mortality → Osteoporosis etc → Impaired mental health → Fatal and non-fatal injuries
Diet-related health problems

- Excess meat
- Low intake of starchy foods
- Low intake of fruit & veg
- Excess fat, especially saturated fat
- Excess sugar
- Excess salt
- Manufactured food products
- Hidden fats, salt & sugar
- Other effects
- Cancers
- Diabetes (type II)
- Obesity
- Ischaemic heart disease
- Stroke

Determinants of the determinants of health

Underlying causes e.g. socioeconomic factors

Determinants (risk factors)

Health status (diseases etc)
Determinants of the determinants of health

Underlying causes e.g. socioeconomic factors

Determinants (risk factors)

Health status (diseases etc)

DALYs and/or Economic valuation

Basic characteristics of diagram

- chains of causation, not just one link
- multiple chains – assumption of independence
  – combination of chains in policy e.g. stick & carrot
- multidisciplinary
- individual & group levels (as is routine in infectious disease epidemiology)
- organised by economic/policy sector
- health determines the content of the diagram – “driven by the bottom line”
Use of diagrams

- flow charts are used for modelling in infectious disease epidemiology, based on differential equations (Anderson & May)
- diagrams in statistics – graphical models
- these are not necessarily explicitly “causal”
- the theory of Directed Acyclic Graphs (DAGs) has developed formal rules for controlling confounding, as rigorous as algebraic formulations, and less error-prone in complicated situations
  - in epidemiology, this has so far used mainly for inferring causation for a single link, but this approach can be expanded to diagrams of larger causal systems
Causal diagrams

• typically “causation” here means that one variable affects the magnitude, probability and/or severity of the next variable
• start simple; build up
  – reduction and expansion – pragmatic
• diagrams are suitable for both qualitative and quantitative analysis
• a diagram is not like a single study, it’s more like a synthesis, => the issue of generalisability
• diagrams evolve from conjectural to well-supported, as evidence is accumulated

Functions of diagrams: scientific

• a framework for analysis, e.g. statistical modelling
• to make assumptions and hypotheses explicit for discussion, and for planning data collection and analysis
• to place hypotheses in the public domain prior to testing – a conjecture that is open to refutation
• to identify evidence gaps
• to generate a research agenda
Functions of diagrams: use for policy

- means of communicating among stakeholders
- to express the connections between policy options and health outcomes, **positive and negative; unintended as well as intended**:
  - to facilitate discussions between experts in different fields, e.g. transport, health; policy areas such as land use, road planning, charging
  - to make judgements explicit
  - to simplify but not over-simplify
  - a check-list, to ensure inclusion of all key items
  - broader than e.g. “evaluation” (1-chain focus)

Relationship to the policy process

- there are various possible models
- the best is a division of labour between the technical assessment and the policy process: for all the possible policy options – including those not currently seen as feasible – a list of the health impacts, including the numbers affected and the severity of effects (economic valuation can be added), information on special risk groups/equity, on reversibility and on possibilities (and costs) for remediation
  - plus the degree of certainty of each component
Determinants of the determinants of health

Underlying causes e.g. socioeconomic factors

Determinants (risk factors)

Health status (diseases etc)

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Altering the determinants of the health determinants

Policy options → alterable causes

Changes in alterable risk factors

Changes in health status
“Change” models: advantages

- **Pragmatism**: changes in the determinants of health determinants link naturally to policy options (cf Wanless: “natural experiments”);
- **Parsimony**: the immense complexity of the pathways can be greatly reduced by focusing on changes, especially in the absence of effect modification;
- **Philosophy**: causality is more readily grasped when something is altered, e.g. a particular road layout rather than “roads” as a necessary condition of “road deaths”.

Effect of the coal ban, Dublin, 1990

- before-after comparison of pollution concentration, adjusted for weather etc
- 72 months before and after the ban
- also controls for influenza and age structure
- all-Ireland controls for secular changes
Transport-related health problems

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Health impact of transport policies

Emissions control policies

Promotion of active transport

Traffic reduction policies

Speed control policies

Δ air pollution
Δ physical activity
Δ community severance
Δ access
Δ noise
Δ collisions: number, severity
Δ resp. morbidity & mortality
Δ cardiovascular morbidity & mortality
Δ osteoporosis etc
Δ impaired mental health
Δ fatal and non-fatal injuries

Emissions control as a technical fix

Emissions control policies

Δ air pollution

Δ resp. morbidity & mortality
Δ cardiovascular morbidity & mortality
Respiratory morbidity & mortality
Cardiovascular morbidity & mortality
Impaired mental health
Fatal and non-fatal injuries
Osteoporosis etc

Air pollution
Physical activity
Community severance
Access
Noise

Lower speed limits
Better enforcement
Traffic calming
Public education

Speed

Collisions: number, severity

Respiratory morbidity & mortality
Cardiovascular morbidity & mortality
Osteoporosis etc
Impaired mental health
Fatal and non-fatal injuries

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Speed

Collisions: number, severity

Respiratory morbidity & mortality
Cardiovascular morbidity & mortality
Osteoporosis etc
Impaired mental health
Fatal and non-fatal injuries
Health promotion initiatives

Agricultural policy
Methodological issues

• need for sensitivity analyses
• combining individual and group (e.g. spatial) levels of analysis
• combining static and “change” evidence
• feedback

A dangerous bend

making the road straighter

\[ \Delta \text{road crashes} \]

\[ \Delta \text{road deaths } \& \text{injuries} \]
A dangerous bend: risk compensation

Making the road straighter

\[ \Delta \text{perceived safety} \]

\[ \Delta \text{road crashes} \]

\[ \Delta \text{increased speed} \]

\[ \Delta \text{road deaths & injuries} \]

John Adams: *Risk*

Feedback

- negative feedback
  - adaptive responses like risk compensation

- positive feedback
  - amplifies the effect
Car dependence

- Community severance
- Unpleasantness & inconvenience of non-car travel
- Reduction of active transport
- Reduction of public transport
- Car dependence affecting e.g. shopping
- Increased car ownership
- Increased prosperity
- Traffic growth
- Congestion

Feedback

- Negative feedback
  - Adaptive responses like risk compensation
- Positive feedback
  - Amplifies the effect
Feedback

• negative feedback
  – adaptive responses like risk compensation

• positive feedback
  – amplifies the effect

• feedback is especially likely
  – (a) with issues that have a substantial behavioural element e.g. drug abuse, violence, obesity;
  – (b) if the policy decision is itself included in the model – analysis of policy – we have been more concerned with health impacts of policy options, i.e. analysis for policy

Thank you!