COMPLEX SYSTEMS APPROACHES TO SUPPORT PUBLIC HEALTH DECISION MAKING

Heather Orpana, PhD
A/Manager, Modelling Unit
Applied Research Division, Public Health Agency of Canada



PROTECTING CANADIANS FROM ILLNESS

Public Health Agency of Canada
Agence de la santé publique du Canada
Canada

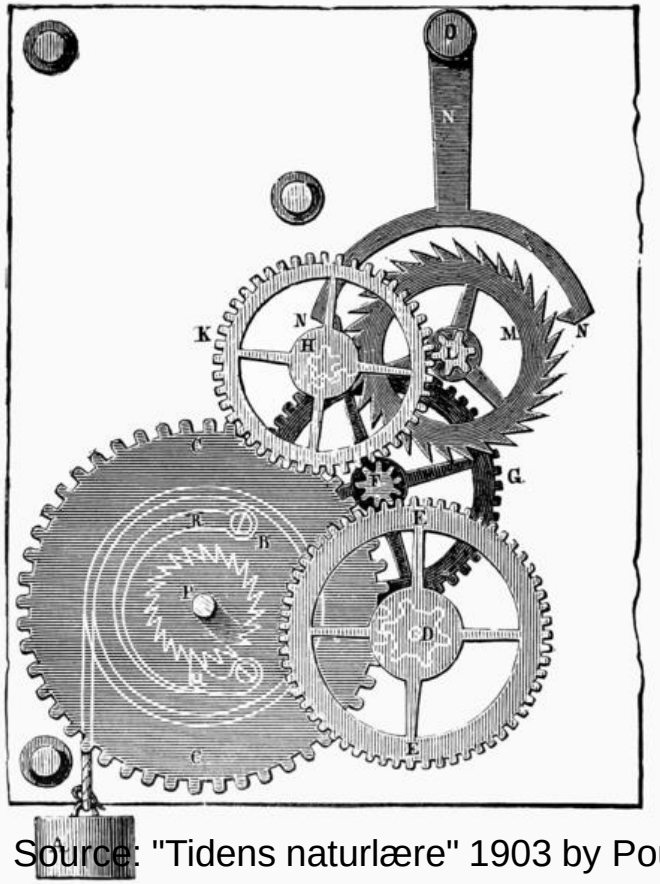
Structure

- Systems
- Complex systems in the context of public health
- Models
- Developing Causal Loop Diagrams (CLDs)
- VENSIM demonstration

WHAT IS A SYSTEMS APPROACH?

What is a system?

- System
  - » A set of interrelated components that interact together and result in achieving a function or an outcome
    - Components (gears)
    - Relationships (how they fit and move together)
    - Function (to tell time)



Source: "Tidens naturlære" 1903 by Poul la Cour
CC0

Types of systems

Type

- Simple
- Complicated
- Complex
- Random

Characteristics of complex systems

- Includes actors/agents (possibly at multiple levels)
- Actors/agents interact
- Behaviour emerges from the interaction of components
- Dynamic (changing) and adaptive
- Non-linear and includes feedback loops
- Side effects (unexpected outcomes; unintended consequences)
- May operate on multiple time scales and levels at the same time
- Some degree of stochastic (random) behaviour

Food for thought: What type of problem?

- Developing a multisectoral partnership to promote healthy weights
  - » Complex
- Developing a policy for screening patients for a new disease
  - » Complicated
- Testing someone for a urinary tract infection
  - » Simple
- Containing an epidemic
  - » Complex

Why use a complex systems approach in public health?

- Many public health problems are complex, while we treat them as complicated
- Some trends in public health that align with a complex systems approach
  - » Wicked problems that are multifactoral
  - » Recognition of a need for multisectoral approaches
  - » Recognition of multiple levels of ecology
  - » Identification of feedback loops
  - » Desire to identify leverage points
  - » Interest in using nudges

Example: Opioid system model

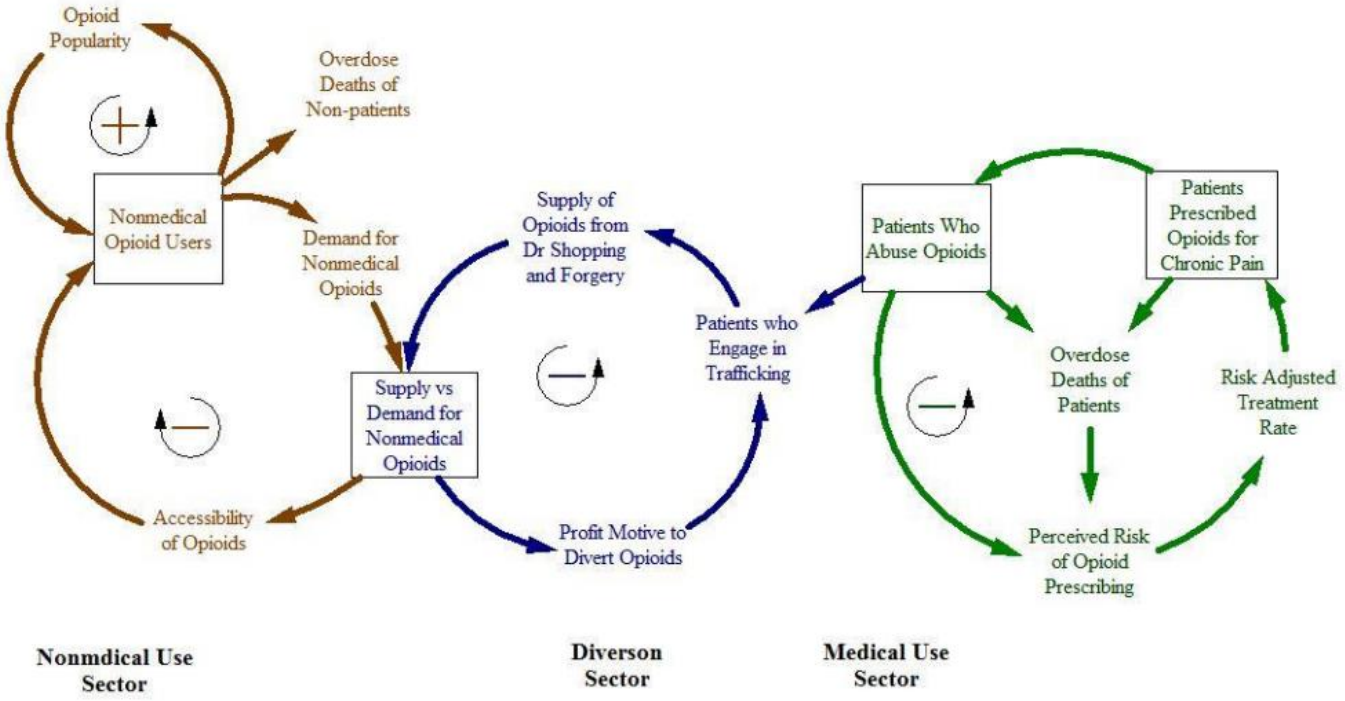
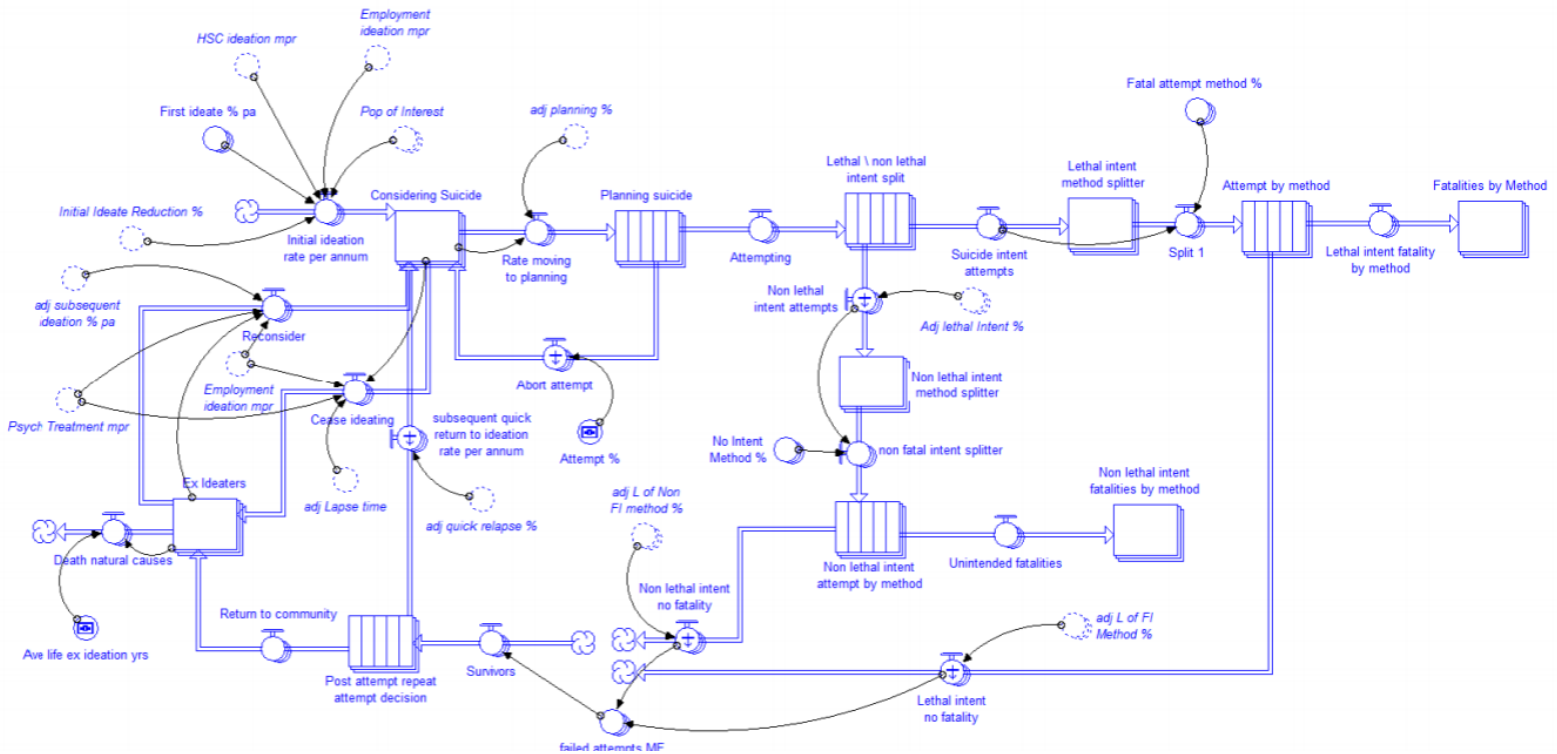


Figure 1: A simple causal loop diagram of the opioid system model shows the relationship among the nonmedical use, diversion and medical use sectors further detailed below.

Source: Wakeland, W., A. Nielsen, T. Schmidt, “System Dynamics Modeling of Medical Use, Nonmedical Use and Diversion of Prescription Opioid Analgesics,” Proc. 30th Int’l Conf. System Dynamics Society, St. Gallen, Switzerland, July 2012.

Example: Suicidal behaviour in Australia

Figure 1: Structure of the model of Australian suicidal behaviour



Source: Page A, Atkinson J, Heffernan M, McDonnell G, Hickie I. A decision-support tool to inform Australian strategies for preventing suicide and suicidal behaviour. Public Health Res Pract. 2017;27(2):e2721717.

Example: Obesity Systems Influence Model

http://www.shiftn.com/obesity/Full-Map.html

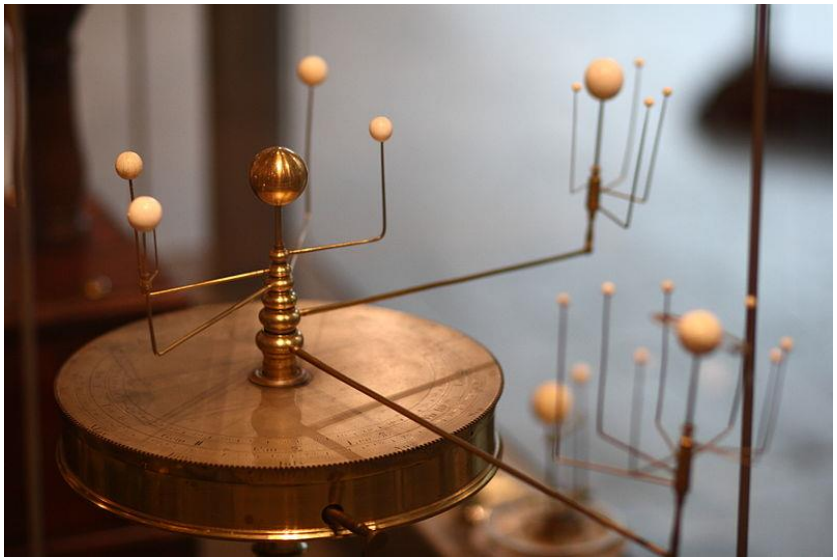
Group activity – 10 minutes

- As a table, choose one of the following problem statements. Discuss whether it could be approached as a simple, complicated, complex or random system.
  - How can we reduce rates of suicide in Canada?
  - A public health problem of your choice
- What are some the attributes of the system that make it simple, complicated, complex or random?

MODELS

What are models?

- Models are simplified representations of real world phenomena
- “All models are wrong but some are useful.”
  - » George Box



CC3.0 photo by Sage Ross
A mechanical planetarium made by Benjamin Martin in London in 1766, used to teach astronomy at Harvard, on display at the Putnam Gallery.

Why is it important to make our mental models explicit?

Public domain: illustrated by Itchō Hanabusa. (1888 Ukiyo-e woodcut)

ONE APPROACH TO MODEL BUILDING

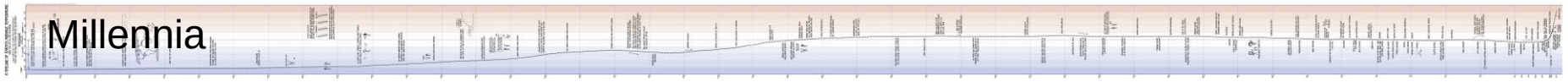
Articulate your problem

- What problem are trying to solve using this model? e.g.
  - How can we reduce rates of suicide in Canada?
  - A public health problem of your choice

Boundaries

- Need to define the boundaries of a system
  - » Systems are often nested within one another
  - » Need to identify the appropriate level of the system for the problem statement at hand
- Can be definite (closed system) or permeable (open system)
- Boundaries are difficult to define, but necessary to avoid including everything and the kitchen sink!

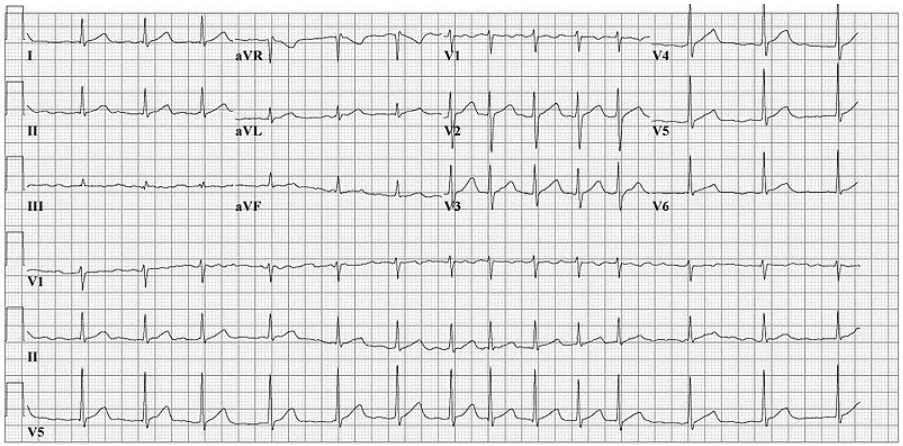
Time scale



Source: XKCD, CC 2.5

Seconds

Source: Predvatel , CC0



Source: CardioNetworks, CC0

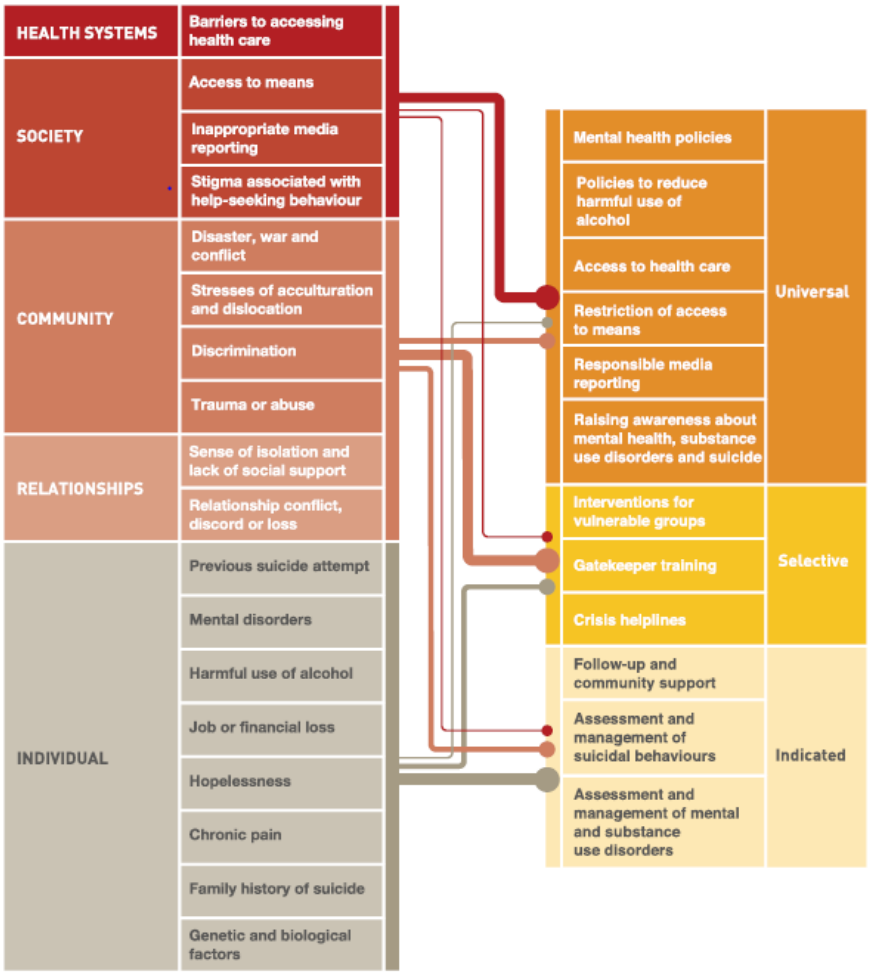
Variables

- What are the elements/variables that need to be reflected in our system?
  - » Endogenous variables interact within the system, influencing other variables
  - » Exogenous variables are not affected by the system but do affect the system

Group activity – 10 minutes

- With respect to your problem statement, identify:
  - Boundaries
  - Time scale
  - Brainstorm the variables that are relevant to the problem statement. Don't be unnecessarily narrow at this point, but keep these to variables that if you changed them, they would have the largest impact on your outcome of interest. Try to use nouns.

Figure 7. **Key risk factors for suicide aligned with relevant interventions**
(Lines reflect the relative importance of interventions at different levels for different areas of risk factors)



Source: WHO, 2014

CAUSAL LOOP DIAGRAMS

Causal loop diagrams

- What are causal loop diagrams?
  - Qualitative representation of a mental model
  - Focusses on causality and feedback loops
  - Includes reinforcing or balancing feedback loops
- Why?
  - Building a model helps to build a common understanding of a problem (makes the implicit explicit)
  - Allows for the identification of the most important factors in a problem
  - Can help identify leverage points for intervention
  - May be a first step before developing a stock and flow diagram for a systems dynamics model

Example: Opioid system model

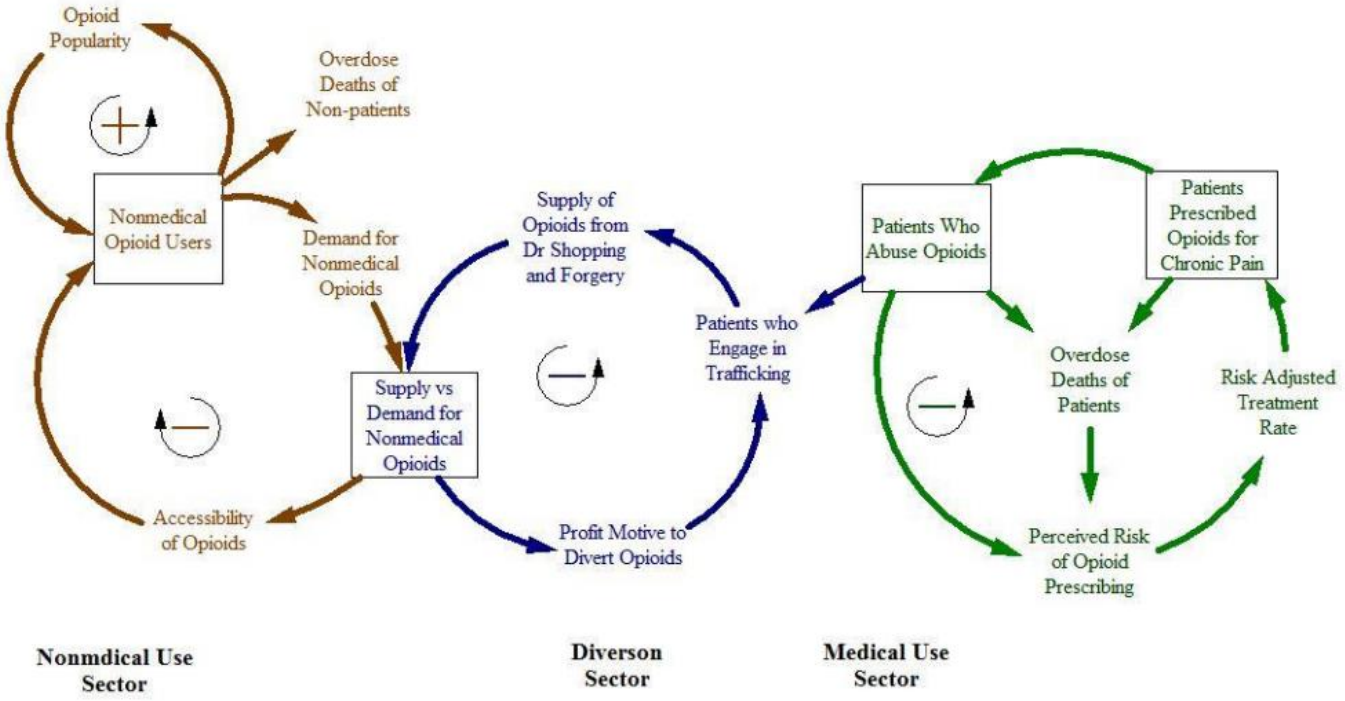


Figure 1: A simple causal loop diagram of the opioid system model shows the relationship among the nonmedical use, diversion and medical use sectors further detailed below.

Source: Wakeland, W., A. Nielsen, T. Schmidt, “System Dynamics Modeling of Medical Use, Nonmedical Use and Diversion of Prescription Opioid Analgesics,” Proc. 30th Int’l Conf. System Dynamics Society, St. Gallen, Switzerland, July 2012.

Causal loop diagrams: process

- Identify “seed structure” → main drivers and outcome
- Build causal loop diagram
- Identify polarity of relationships (positive, negative)
- Identify feedback loops (reinforcing, balancing)

Seed structure

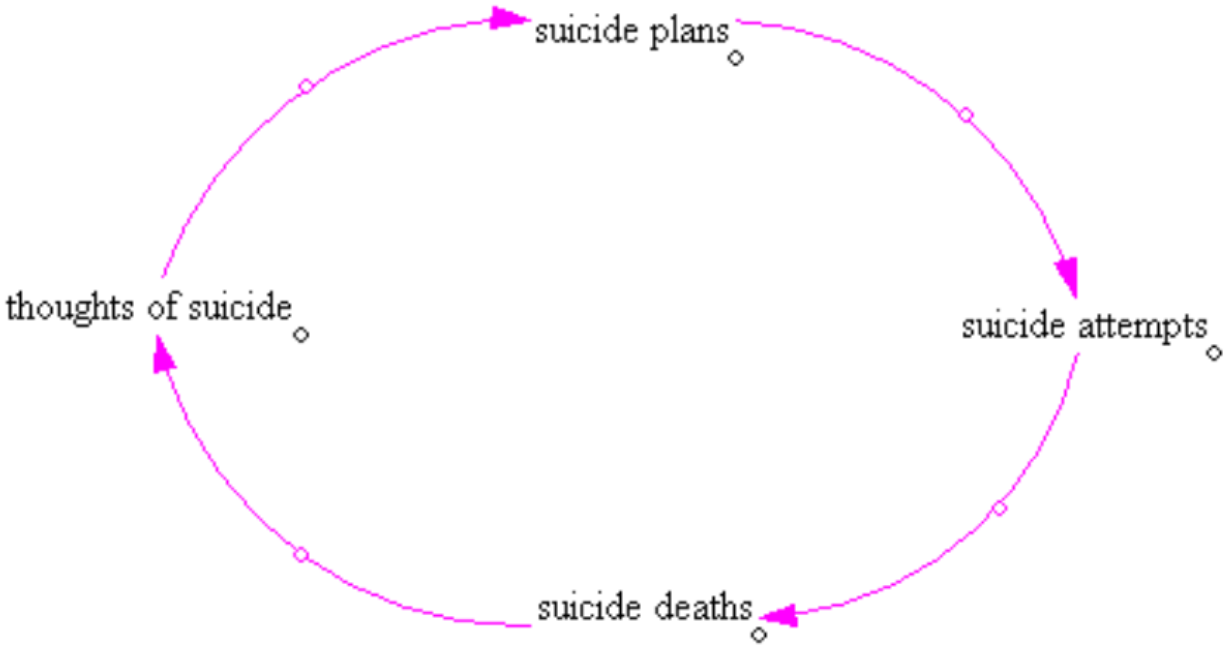
suicide contagion

media guidelines

media reporting of suicide

help seeking

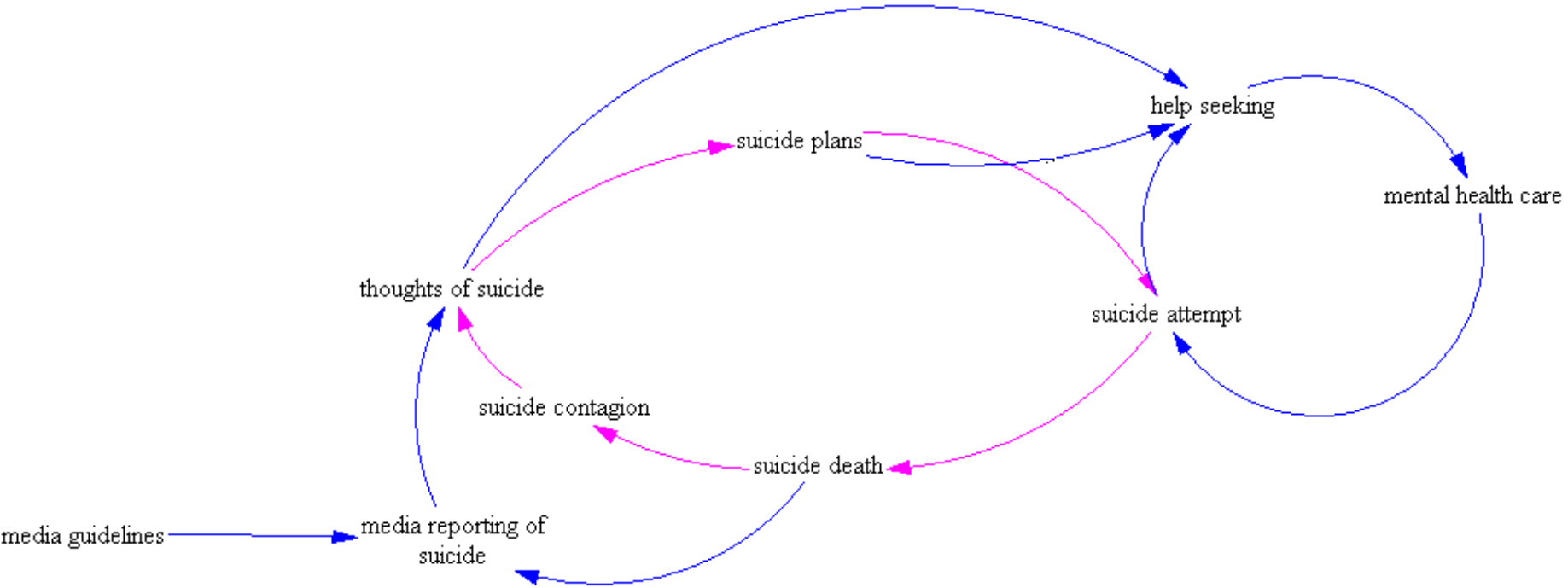
mental health care



Causal loop diagrams: process

- Identify “seed structure” → main drivers and outcome
- Build causal loop diagram
- Identify polarity of relationships (positive, negative)
- Identify feedback loops (reinforcing, balancing)

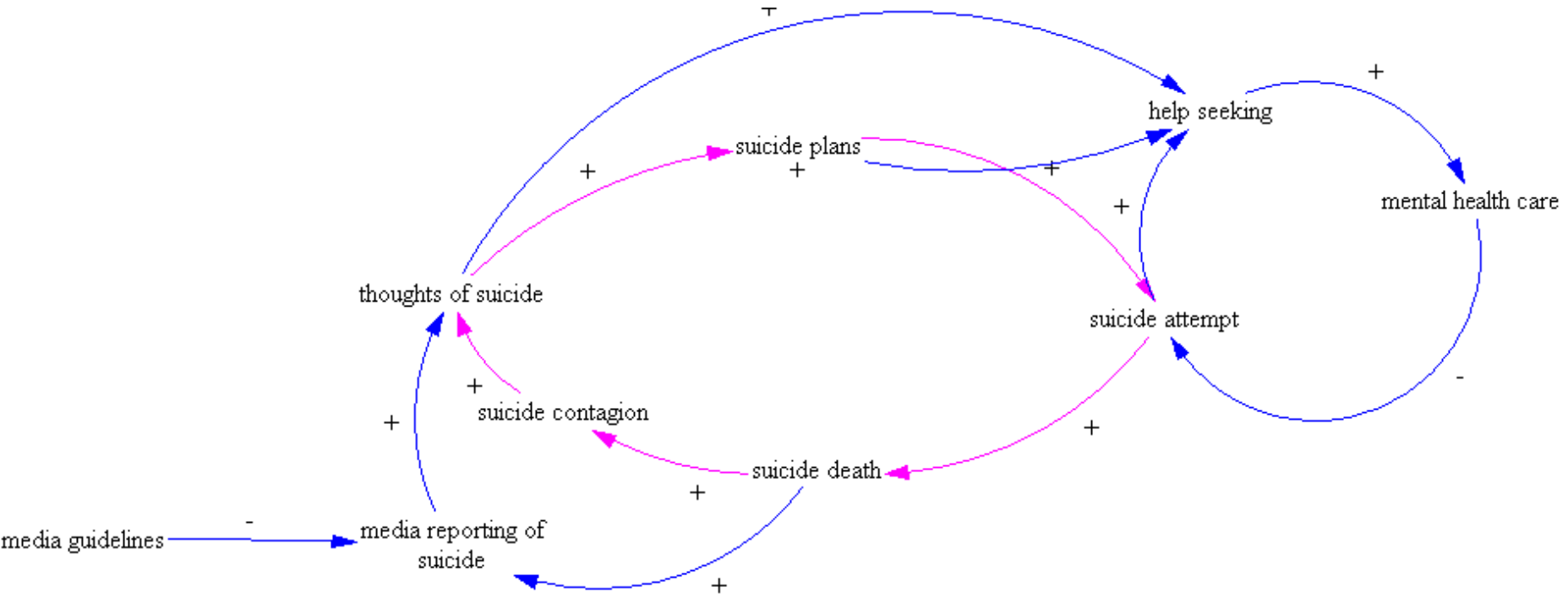
Build causal loop diagram



Causal loop diagrams: process

- Identify “seed structure” → main drivers and outcome
- Build causal loop diagram
- Identify polarity of relationships (positive, negative)
- Identify feedback loops (reinforcing, balancing)

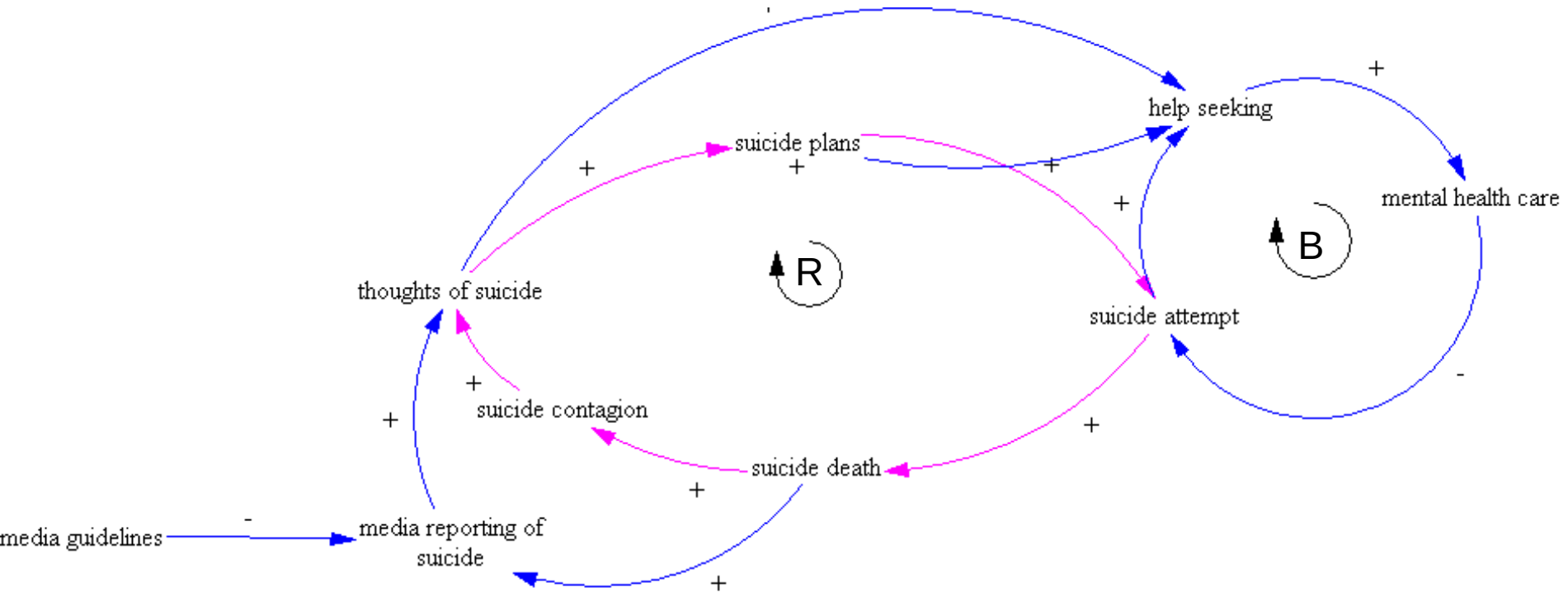
Identify polarity of relationships



Causal loop diagrams: process

- Identify “seed structure” → main drivers and outcome
- Build causal loop diagram
- Identify polarity of relationships (positive, negative)
- Identify feedback loops (reinforcing, balancing)
  - » Reinforcing if all relationships are positive or there is an even number of negative relationships (accelerator)
  - » Balancing if an odd number of negative relationships (brakes)

Identify feedback loops



Group activity – 15 minutes

- Using the variables that you have identified in the previous activity, start to construct a causal loop diagram related to your problem statement.
- Choose a rapporteur to present your model back to the group.

- Identify “seed structure” → main drivers and outcome
- Build causal loop diagram
- Identify polarity of relationships (positive, negative)
- Identify feedback loops (reinforcing, balancing)
  - » Reinforcing if all relationships are positive or there is an even number of negative relationships (accelerator)
  - » Balancing if an odd number of negative relationships (brakes)

Personal reflection

- What was your experience building your model with your group?
- Did you discover anything surprising?
- Did everyone have the same mental model of the problem?
- What did different perspectives contribute to the understanding of the problem?

VENSIM DEMO

VENSIM

- VESIM is software that can be used to create causal loop diagrams and system dynamics models
- Personal learning version of the software can be downloaded for free
- https://vensim.com/free-download/

THANK YOU

Heather Orpana
Heather.orpana@phac-aspc.gc.ca
613-878-5011