CONCEPTUAL MODELS: THE RELATIONSHIP BETWEEN BUILT ENVIRONMENT AND HEALTH
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ACKNOWLEDGEMENTS

Conceptual Models:

Source:
From Built Environment To Health: An Evidence and Best Practices Based Review
Lawrence Frank and Company, December 2007

Created by:
Paul Conway – Office of Public Health Practice
Public Health Agency of Canada – January 2008

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DESCRIPTION OF PROCESS

Systems thinking is an approach for viewing and understanding the real world, and its associated issues and problems through the construction, analysis, and communication of models. Models are excellent illustration techniques for identifying component parts of a system. Component parts are best understood within the context of their relationships with other system parts, rather than in isolation. Consistent with systems philosophy, systems thinking concerns an understanding of a system by examining the linkages and interactions between the variables that compose the entirety of the overall system.

Systems thinking attempts to illustrate that events are separated by distance and time and that small catalytic events can cause large effects in complex systems. Acknowledging that an improvement in one area of a system can adversely affect another area of the system, it promotes organizational communication at all levels in order to avoid the silo effect. Systems thinking techniques may be used to study any kind of system — natural, scientific, engineered, human, or conceptual.

Peel Region has been applying systems thinking to better understand the effects of urban form on the health of populations. The report entitled First Draft of Evidence and Best Practices Review, by Lawrence Frank and Company was used as the basis for the systems-based modelling activities. The modelling activities applied a top-down/ bottom-up approach in which the following tasks were conducted: document analysis, identification of components and component parts, illustration of components and component parts, illustration of component part relationships, and illustration of component relationships.

Document analysis consisted of gaining contextual knowledge of the document’s contents. Components were determined by the subject headings, or chapters, of the Lawrence Frank and Company report. The component parts were determined by the section or paragraph heading of each component and referenced on the models by page number (appearing within brackets). Component parts relationships were determined through the understanding of variable relationships, either positive (reinforcing) or negative (balancing), as identified by studies referenced within the report. Finally, component relationships were aggregated based on the estimation of requirements by the modelling authority without direction from Peel Region. A final high-level aggregate (Contextual Model) was then synthesized, without Peel Region direction, from the four component models thereby completing the top-down/ bottom-up approach.

The components consist of Built Environment - Neighbourhood Design, Air Pollution, Pedestrian Safety, and Mental Health.
The component parts of Built Environment – Neighbourhood Design are: Neighbourhood Design, Other Influential Factors, Building and Site Design, Street Design and Pedestrian/ Cyclist Facilities, Floor Area Ration, Health Impacts of Obesity, Physical Activity, Diet and Body Weight, Overall Neighbourhood Walkability, Street Connectivity, Density and Land Use Mix, Transit Service and Street Design/ Pedestrian Facilities.

The component parts of Air Pollution are: Exposure to Air Pollution, Per Kilometer Pollution Emission Rates, Regional Air Pollution, Localized Air Pollutants, Factories, Power Plants and Rail Corridors, Micro-Environmental Conditions, Regional Air Pollution (2), Global Air Pollution, Health Impacts of Air Pollution, Deviation from Weather Norms, Neighbourhood Walkability Index, Vehicle Miles Travelled, Access to Public Transit, Employee Transit/ Ridesharing, Employment Centers, Vehicle Miles Travelled (2), Walkability Index (2), Residential Density, Key Outcome Indicators, Key Outcome Indicators (2), Health Benefit Conflict, and Employment Density.


The component parts of Mental Health are: Community Social Support, Proximity to Nature, Time Spent Driving, Physical Activity, and Time Spent Driving (2).

Paul Conway, Office of Public Health Practice
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THE MODELS
Overview Model: From Built Environment to Public Health

(Layer 1)
From Built Environment to Public Health

Source:
First Draft of Evidence and Best Practices Based Review
Lawrence Frank and Company, December 21, 2007

Conceptual Model Adaptation:
Paul Conway—Office of Public Health Practice
Public Health Agency of Canada, January 29, 2008
Aggregate Models:

Physical Activity / Neighbourhood Design
Air Pollution
Pedestrian Safety
Mental Health

(Layer 2)
Causal Loop Model
Layer: Mental Health

Proximity to Nature (41)
- Access to Nature
- Ability to Cope With Stress
- Residents With Back Yards
- Size Of Yard
- Distance From Urban Core

Community Social Support (41)
- Access to Green Space/ Open Space
- Desire to Walk Cycle
- Participation in Social Activities
- Personal Feeling Of Security
- Neighbourhood Variability
- Community Cohesiveness
- Drug/Alcohol Use/ Crime
- Control Over Life
- DaytoDay Stress
- Dependence Upon Others
- Viable Transportation Options
- Land Use Patterns
- Residential Density
- Income
- Ability to Afford a Car

Time Spent Driving (40)
- Time Off Of Work
- Incidence Of Mental Illness
- Blood Pressure
- Jobs Performance
- Office Frustration
- Cars On the Road
- Time Pressures
- Frustration
- Sense of Being in Control During Commute
- Predictability of Traffic Conditions
- Other Driver Habits

Source:
First Draft of Evidence and Best Practices Based Review
Lawrence Frank and Company, December 24, 2007
Conceptual Model Adaptation:
Paul Conway—Public Health Agency of Canada, January 29, 2008

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Subcomponent Models

The aggregate models have been repeated in this section for ease of comprehension

(Layer 3)
Physical Activity / Neighbourhood Design
Causal Loop Model
Layer – Design Patterns: Neighbourhood, Street, Building/ Site (6,7,8) – Page 1

Other Influential Factors (7)

- Sidewalk Presence
- Neighbourhood Walkability
- Effective Streetscape Design
- Transit Accessibility
- Visual Quality
- Site Design
- Building Placement

Neighbourhood Design (6)

- Density
- Neighbourhood Destination Proximity
- Activity Options
- Land Use Mix

Street Connectivity
- Directness
- Neighbourhood Destination Distance
- Convenience of Walking
- Number of Walking Trips
- Vehicle Miles Travelled

- Auto Use
- Mode of Transport Options

Building and Site Design (8)

- Ground Floor Windows
- Balconies
- Proximity to Street
- Entrance Distance From Parking Lot
- Perception of Safety/ Security

- Visual Appeal
- Greenery
- Landscaping
- Entrance Distance From Sidewalk
- Number of Entrances

Systemic flow
- Second variable value flows in the same direction as the first
- Second variable value flows in the opposite direction as the first

Source:
First Draft of Evidence and Best Practices Based Review
Lawrence Frank and Company, December 21, 2007

Conceptual Model Adaptation:
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Causal Loop Model
Layer – Design Patterns: Street and Pedestrian/Cycling Facilities (7) – Page 2

Street Design and Pedestrian/Cyclist Facilities (7)

Source:
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Lawrence Frank and Company, December 24, 2007

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Causal Loop Model
Layer—Design Patterns: Floor Area Ratio, Physical Activity, Walkability, Connectivity – Page 3

Health Impacts of Obesity (13)

- Economic Burden of Disease/illness
- Premature Death/Disabilities
- Overweight/Obese Population
- Incidence of Obesity Associated Disease
- Health Care Costs
- Demand on Health System
- Patient Wait Times

Physical Activity, Diet and Body Weight (13)

- Access
- Healthy Food
- Calories Consumed
- High Calorie/High Fat/High Sugar Diet
- Body Weight
- Risk of Obesity
- Mortality Rates

Floor Area Ratio (9)

- Total Floor Area
- Floor Area Ratio
- Commercial/Office Site Development Density
- Total Land Parcel Area

Street Connectivity (17)

- Density
- Proximity to Neighbourhood Retail
- Compact Mixed Use Development
- Driving for Errands
- Walking for Errands

Overall Neighbourhood Walkability (14)(15)

- Mixed Land Use
- Residential Density
- Walkability Measure
- Time Spent Conducting Physical Activity
- Neighbourhood Walkability

Source:
First Draft of Evidence and Best Practices Based Review
Lawrence Frank and Company, December 21, 2007

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Causal Loop Model
Layer – Design Patterns: Density/Land Use Mix, Transit and Street Design – Page 4

Density and Land Use Mix (15,16)

- Time Spent Walking
- Number of Walking Trips
- Area Walkability
- Public Transit Ridership
- Public Transit Use
- Number of Transit Related Walking Trips

- Likelihood of Weight Gain
- Time Spent Driving
- Auto Use

- Retail Floor Area Ratio
- Residential Density
- Education Facilities
- Restaurants
- Grocery Stores
- Retail Facilities
- Parks
- Land Use Mix
- Destination Options
- Units Per Acre

Systemic flow
- Second variable value
  + flows in the same direction as the first
- Second variable value
  - flows in the opposite direction as the first

Transit Service (17)

- Public Access to Transit
- Distance
- Time Spent Walking
- Physical Activity Level
- Health Benefits
- Physical Activity Level
- Walking Level
- Effective Street Design
- Safety Perception
- Neighbourhood Attractiveness
- Crossing Lights
- Street Design/ Pedestrian Facilities (17)

Source:
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Lawrence Frank and Company, December 21, 2007

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Air Pollution
Contextual Model
Layer – Air Pollution – Local, Micro Conditions (21)

Localized Air Pollutants (21)
- Per Capita Emission Production
- Exposure Rates
  + Development Density

Factories, Power Plants and Rail Corridors (21)
- Localized Air Pollutants
- Particulate Matter
  - Carbon Monoxide
  - Lead
- Airborne Toxins
- Concentration Near Source
- Health Risk
- Proximity to Population
- Amount of Pollution

Source:
First Draft of Evidence and Best Practices Based Review
Lawrence Frank and Company, December 21, 2007
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Micro-Environmental Conditions (21)
- Speed
  - Traffic Conditions
  - Vehicle Mix
  - Rain
  - Emission Levels
- Climatic Conditions
  - Wind
  - Exposed Potential
  - Time Spent Walking/Cycling

Regional Air Pollution (21)
- Wind Speed
  - Wind Direction
  - Upwind Pollution Source
- Regional Air Pollutants
  - Concentrations
  - Area Geography
  - Area Weather/Climate Conditions

Systemic flow
- Second variable value flows in the same direction as the first
- Second variable value flows in the opposite direction as the first
Contextual Model
Layer – Air Pollution – Global, Health Impacts (21, 22)

Global Air Pollution (CO2)
- Climate Change
- Food Security
- Displaced Population

Global Air Pollution (21, 22)
- Natural Disaster Risk
- Disease Rates
- Health Impacts

Deviation From Weather Norms (23, 24)
- CO2 Emissions
- Greenhouse Gas Emissions
- Severity/ Extremes of Weather Events

Potential Negative Impacts on Habitats/ Food Production

Health Impacts of Air Pollution (23)
- Airborne Fine Particulate Matter
- Ozone Level
- Pollution Level
- Population Vulnerability
- Lung Function Effectiveness
- Incidence Of Respiratory Disease
- Elderly
- Youth
- Breathing Levels
- Outdoor Exercise
- Hospital Admissions
- Health Care Costs
- Premature Deaths

Source:
First Draft of Evidence and Best Practices Based Review
Lawrence Frank and Company, December 21, 2007

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Contextual Model
Layer – Air Pollution – Exposure, Emission Rates, Regional Levels (21)

Exposure to Air Pollution (21)

Per Kilometre Pollution Emission Rates (21)

Regional Air Pollution (21)

Wind Speed

Wind Direction

Upwind Pollution Source

Great Lakes Basin Climate Conditions

Regional Air Pollutants

Area Weather/Climate Conditions

Area/Local Pollution Levels

Concentrations

Area Geography

Source:
First Draft of Evidence and Best Practices Based Review
Lawrence Frank and Company, December 21, 2007

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Contextual Model
Layer – Air Pollution – Neighbourhood Walkability, VMT, Employment Centres (25)

Source:
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Lawrence Frank and Company, December 21, 2007

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Contextual Model
Layer – Air Pollution – Density, Key Outcome Indicators (26, 27, 33)

Source:
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Lawrence Frank and Company, December 21, 2007

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Pedestrian Safety
Contextual Model
Layer – Pedestrian Safety – Traffic, Safety, Health Impacts (34)

Auto Use
Traffic Volume
Road Capacity
Congestion
Speed of Travel
Severity of Collisions

Severity of Collisions (34)

Pedestrian Safety (34)

Appropriateness of Active Transportation Infrastructure

Pedestrian Safety

Speed of Traffic

Per Capita Traffic Fatality Rates
Distance
Travel Options
Per Capita Vehicle Travel

Pedestrian Exposure to Traffic (34)

Health Impacts of Traffic Crashes (34)

Likelihood of Being in An Accident
Age
Potential Years of Lost Life
Frailty
Male Deaths
Children/ Young Adult Deaths

Likelihood of Being Killed

Per Capita Travel Miles
Compact Mixed Use Community
Community Sprawl

Safety of Walking Environment (34)

Traffic Safety
Safety of Walking Environment
Personal Sensitivity
Physical Activity
Assistive Walking Device Use

Speed of Movement
Age

Systemic flow
Second variable value
* flows in the same direction as the first
Second variable value
* flows in the opposite direction as the first

Source:
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Traffic Speed, Volume and Street Design (35)

- Speed of Travel
- Maximum Speed That Feels Safe to Motorists
- Severity of Collisions
- Probability of Vehicle Related Death
- Number of Collisions

- Enforcement Of Speed Limits
- Presence of Other Feature Activities
- Design Speed of Road
- Sidewalks
- Pedestrian Exposure to Traffic
- Perceived Safety
- Pedestrian-Vehicle Collisions

- Street Trees
- Parallel Parking
- Traffic Clamping

- Traffic Speed, Volume and Street Design (35)
- Congestion
- Maximum Speed That Feels Safe to Motorists
- Severity of Collisions
- Probability of Vehicle Related Death
- Number of Collisions

-系统流
- 第二变量值
- 流动方向与第一个相同
- 第二变量值
- 流动方向与第一个相反

Source:
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Contextual Model
Layer – Pedestrian Safety – Intersection Safety (36)

Intersection Safety (36)

Intersection Turning Radius

Intersection Design

Length Of Time

Cross Walk Signal

Refuge Medians

Pedestrian Volume

Pedestrian Ability To Cross The Intersection

Vulnerability Of Population

Disabled Youth

Elderly

Intersectional Vehicle/Pedestrian Collisions

Pedestrian Safety

Ability to Stop

Speed at Intersection

Speed of Travel

Traffic Calming Effectiveness

Traffic Volume

Speed Limit

Road Capacity

Road Width

Street Design

Congestion

Systemic flow

- Second variable value flows in the opposite direction as the first

+ Second variable value flows in the same direction as the first

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Contextual Model
Layer – Pedestrian Safety – Crash Risk, Driver Awareness, Intervention (37, 38)

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Mental Health
Contextual Model
Layer – Mental Health – Physical Activity, Driving, Proximity to Nature (40, 41)

Proximity to Nature (41)
- Risk of Mental Health Issues
- Ability to Cope with Stress
- Access to Nature
- Availability
- Size of Yard
- Residences With Back Yards
- Distance From Urban Core

Time Spent Driving (40)
- Office Frustration
- Blood Pressure
- Incidence of Illness
- Time off Work
- Demand For Health Services
- Other Driver Habits
- Frustration
- Time Pressures
- Congestion
- Sense Of Control
- Time Spent Commuting in Car
- Desire to Drive
- Attractiveness of Other Transportation Options

Physical Activity (40)
- Regular Physical Activity
- Stress, Anxiety, Depression

Source:
First Draft of Evidence and Best Practices Based Review
Lawrence Frank and Company, December 21, 2007

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Contextual Model
Layer – Mental Health – Community Social Support (41)

Source:
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Lawrence Frank and Company, December 21, 2007

Conceptual Model Adaptation:
Paul Conway – Public Health Agency of Canada, January 29, 2008
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