Smoothing rates and disease mapping

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Disease mapping

- Analysis of the spatial variation of disease incidence or mortality
- Its subsequent representation on a map

Population/public health
Health or health service outcomes
Health service utilization
Survival rates
Others

Disease mapping: retrospective study

- A fixed time frame (time window of 5 or 10 years)
- Disease risks of local areas of a region under study
- Underlying geographical distribution of disease incidence/mortality rates

Applications:

- Disease and health outcome epidemiology and surveillance (disease or injury incidence, mortality, etc)
- population health study (disease, injury, low birth-weight rate, etc)
- Health service research (health outcomes, service utilization, etc)

The Data: (simple spatial design)

- Y_i **:** number of disease incidence or mortality in health region *j, j* = 1,…,J (J regions under study)

- N_i *:* the corresponding "population at risk" (often the mid-period population estimate)

- X_j: the covariates

Objective:

Explore spatial risk clusters; identify high risk regions and risk factors

The Data: (spatial design with age effects)

- Y_{jk} **:** number of disease incidence or mortality for age group k (k = 1, …, K) and in health region *j, j* = 1,…,J (J regions under study)

- N_{ik} *:* the corresponding "population at risk" (often the mid-period population estimate)

- X_{jk}: the covariates

Objective:

Explore spatial risk clusters; identify high risk regions and risk factors (age specific or adjusted)

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The Data: (spatio-temporal design)

- Y_{jt} : number of disease incidence or mortality in health region *i* and year *t* (eg. *t* =1991,…,2000);
  (For HSDA, for example, *j* =1,…,16)

- N_{jt} *:* the corresponding "population at risk" (often the mid-year population estimate)

- X_{jt}: the covariates

Objective:

Model non-linear rate trends; uncover evolution of spatial risk clusters

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The Data: (spatio-temporal design with age effects)

- Y_{jkt} : number of disease incidence or mortality

- N_{jkt} : the corresponding "population at risk" (often the mid-year population estimate)

- X_{jkt} : the covariates

Focus

- Understand disease occurrence

  Area-specific rates are assessed as an *ensemble*

- Assess spatial variation of disease risks
- Predict disease risk over space and time
- Capture spatial patterns evolving over time
- Evaluate health services outcome and resource utilization

Important Issues

- The areal units (Administrative health regions)
- The measures used for the construction of disease map
- The precision of measurement
- Trade-off between resolution of the data and precision of measurement

Map

- True underlying spatial variation?
- Chance variation?
- Artifacts of the “at-risk population” variation?

Simple Statistical Representation

- Crude rate: Y_j/N_j , $j = 1,2,\ldots,J$

Frequency of disease occurrence in the j-th local area

- 'Global' mean rate (BC rate for example): m

$$m=\text{sum}(Y_j)/\text{sum}(N_j)$$

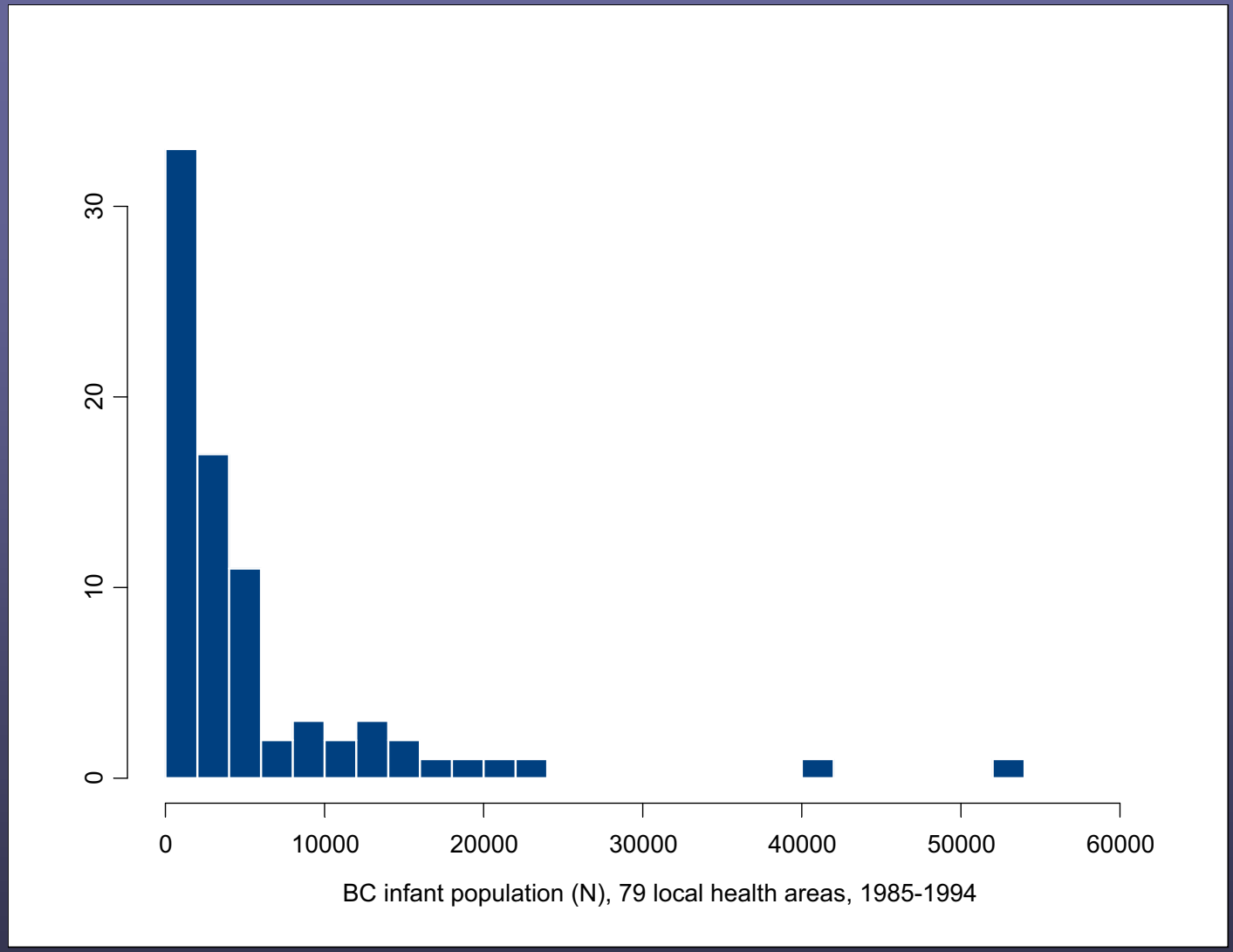
- Rate ratio (also called relative risk):

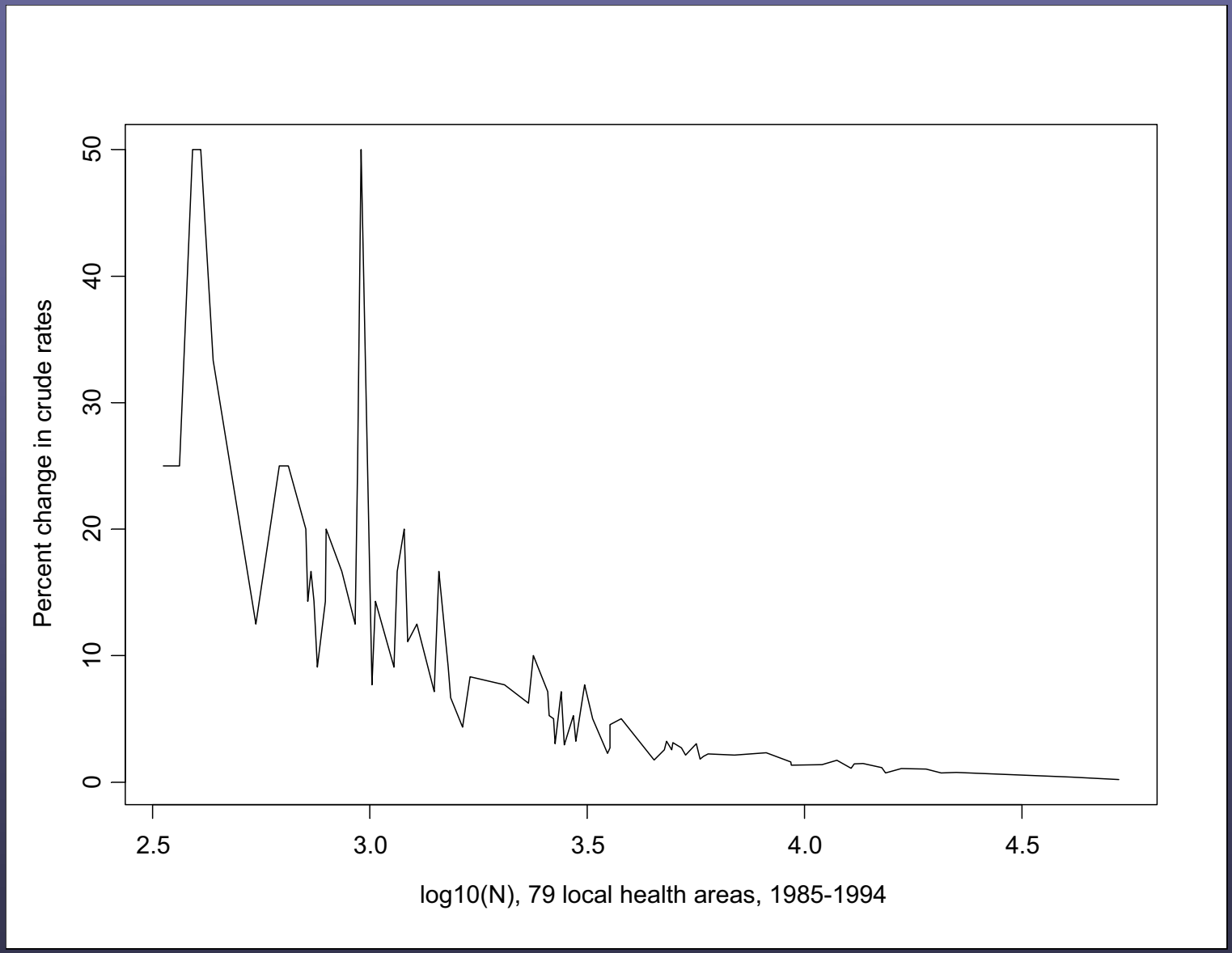
$$RR_j = (Y_j/N_j) / m$$

Ratio of local area rate over 'global' mean rate or ratio of observed cases/expected cases

Limitations of the Simple Statistics

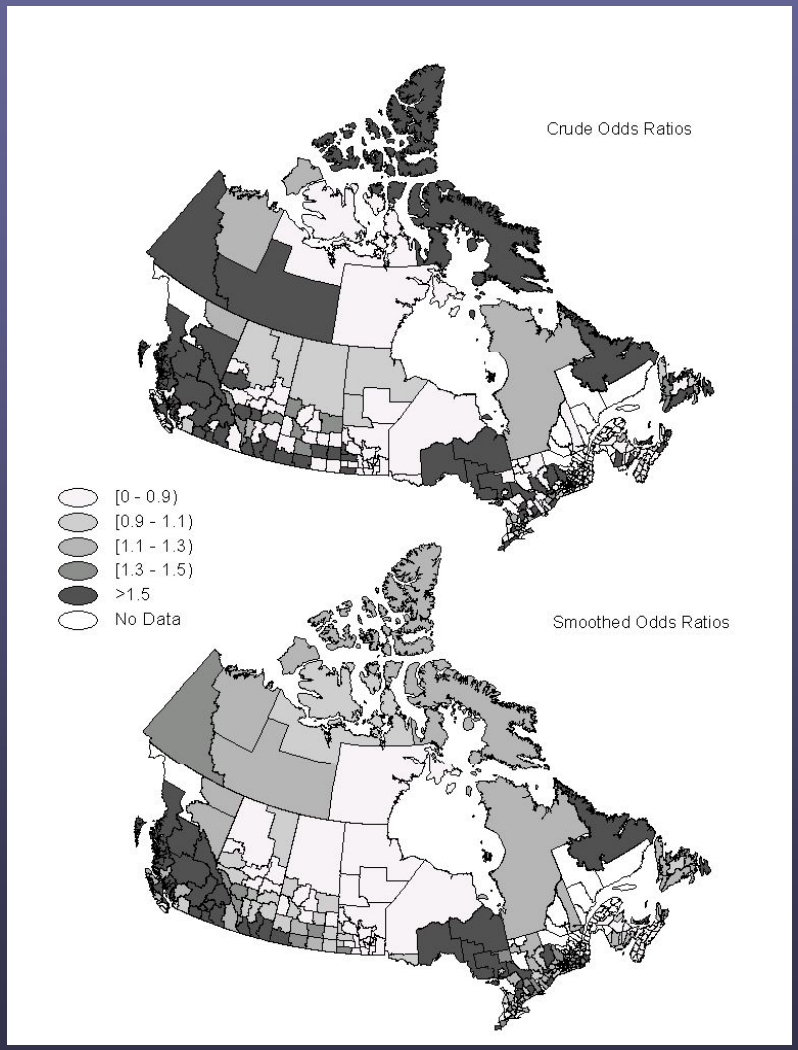
- Crude rates or ratios may have poor precision when rare diseases are investigated in small areas
- Areas of low population tend to present extreme rates/ratios, which may not reflect truly elevated disease risk
- Rates with large chance variation tend to highlight the map
- Such map does not yield meaningful/useful interpretation


0
10
20
30
0
10000
20000
30000
40000
50000
60000
BC infant population (N), 79 local health areas, 1985-1994


Percent change in crude rates
0
10
20
30
40
50
2.5
3.0
3.5
4.0
4.5
log10(N), 79 local health areas, 1985-1994

Chronic Lung disease, Canadian NICU data, 1996-1997

Smoothed ratios obtained via hybrid Markov Chain Monte Carlo algorithm



Model-based disease mapping (Bayesian)

- Predict the local area risks ***ensemble*** in an optimal way
- Separate systematic variability from random noise, a component that usually overshadows the crude maps
- Produce `clean' maps, `clean' of random noise and any artifacts of population variation
- `Borrow' strength and smoothing

  Spatial smoothing

  Non-spatial “Global” smoothing

Bayesian ecological regression

- Examine response-covariate association
- Identify regional determinates (or sources of relative risk variation)
- Contrast unadjusted and (risk) adjusted relative risks (quantify sources of RR variations)

Spatio-temporal models

(Spatio-temporal smoothing)

- Model non-linear rate trends (both “global” and “local”)

  BC study for example:

  global rates: annual BC rates
  local rates: annual LHA rates

- Uncover evolution of spatial risk clusters

Neonatal Health Services in Canada

Use Bayesian hierarchical methodologies to

- examine hospital variations in neonatal intensive care unit (NICU) outcomes and utilization rates in Canada
- assess geographic variations of adverse birth outcomes, NICU outcomes and NICU resource use
- link practice patterns to outcome variations
- develop a national neonatal health geographical information system (GIS)

Canadian Neonatal Database

- Population-based:

  20 488 admissions (19 507 infants) Jan 96 – Oct 97

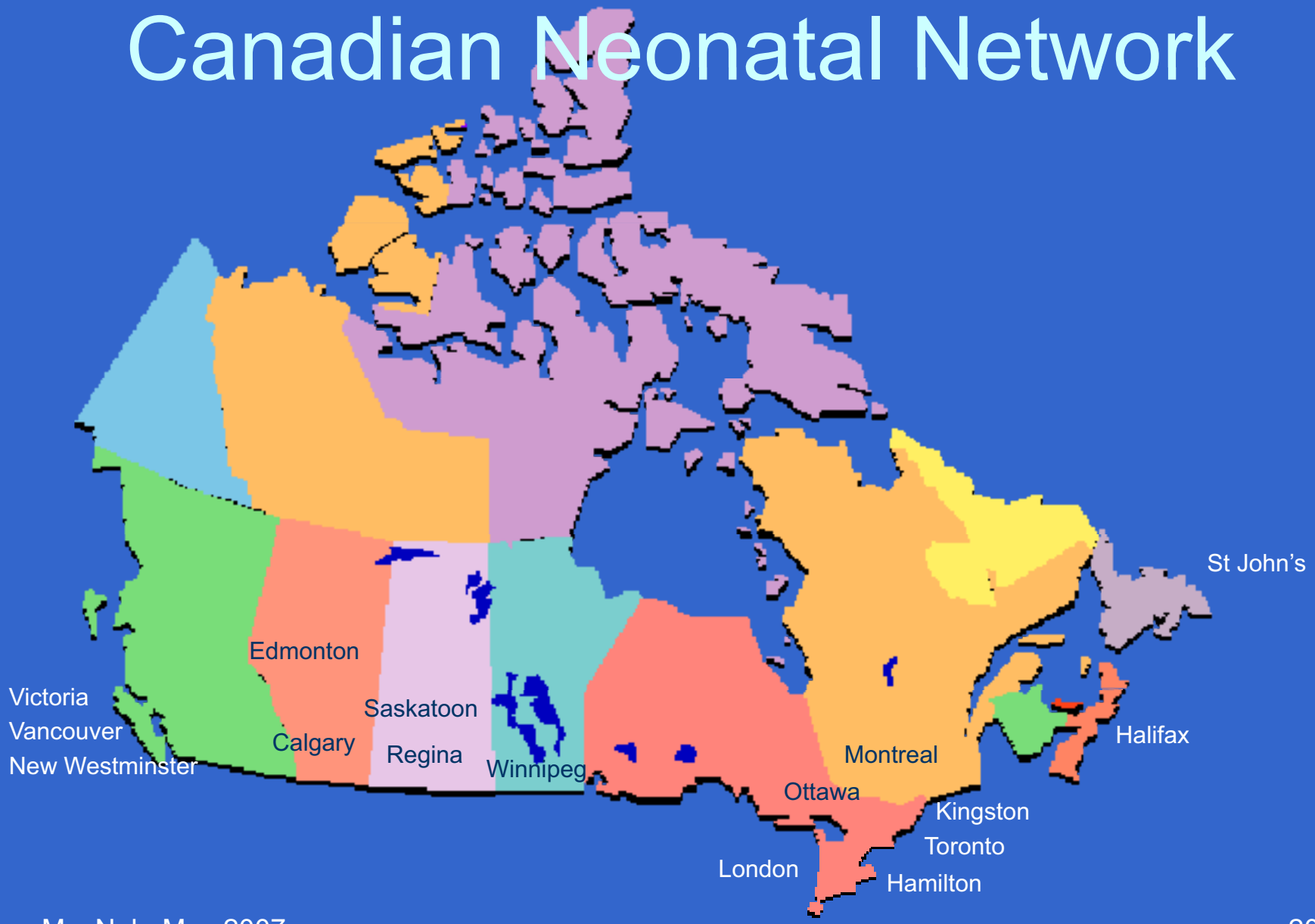
  17 NICUs across Canada (75% tertiary level NICU beds)

- Detailed patient information:

demographic information, antenatal history, mode of delivery, problems at delivery, illness severity, selected NICU practices and procedures, therapeutic intensity, use of technology and resources, selected patient outcomes

- Hospital characteristics:

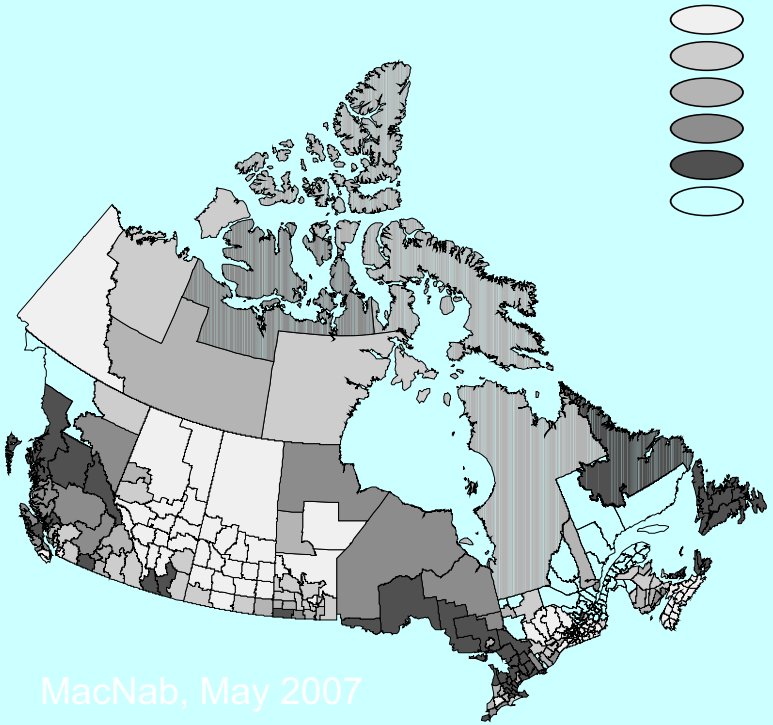
Canadian Neonatal Network



Intraventricular hemorrhage incidence, Canadian NICU data, 1996-1997

- *Ratios obtained via hybrid Markov Chain Monte Carlo algorithm.*
- *Adjusted ratios: adjusted for VLBW, LBW, outborn, SGA, SNAP-II >20.*

Unadjusted Ratio



Adjusted Ratio

Burden of Injury in BC and Its Local Communities: Information and Evidence for Community-based Prevention Strategy, Health Policy and Service Provision

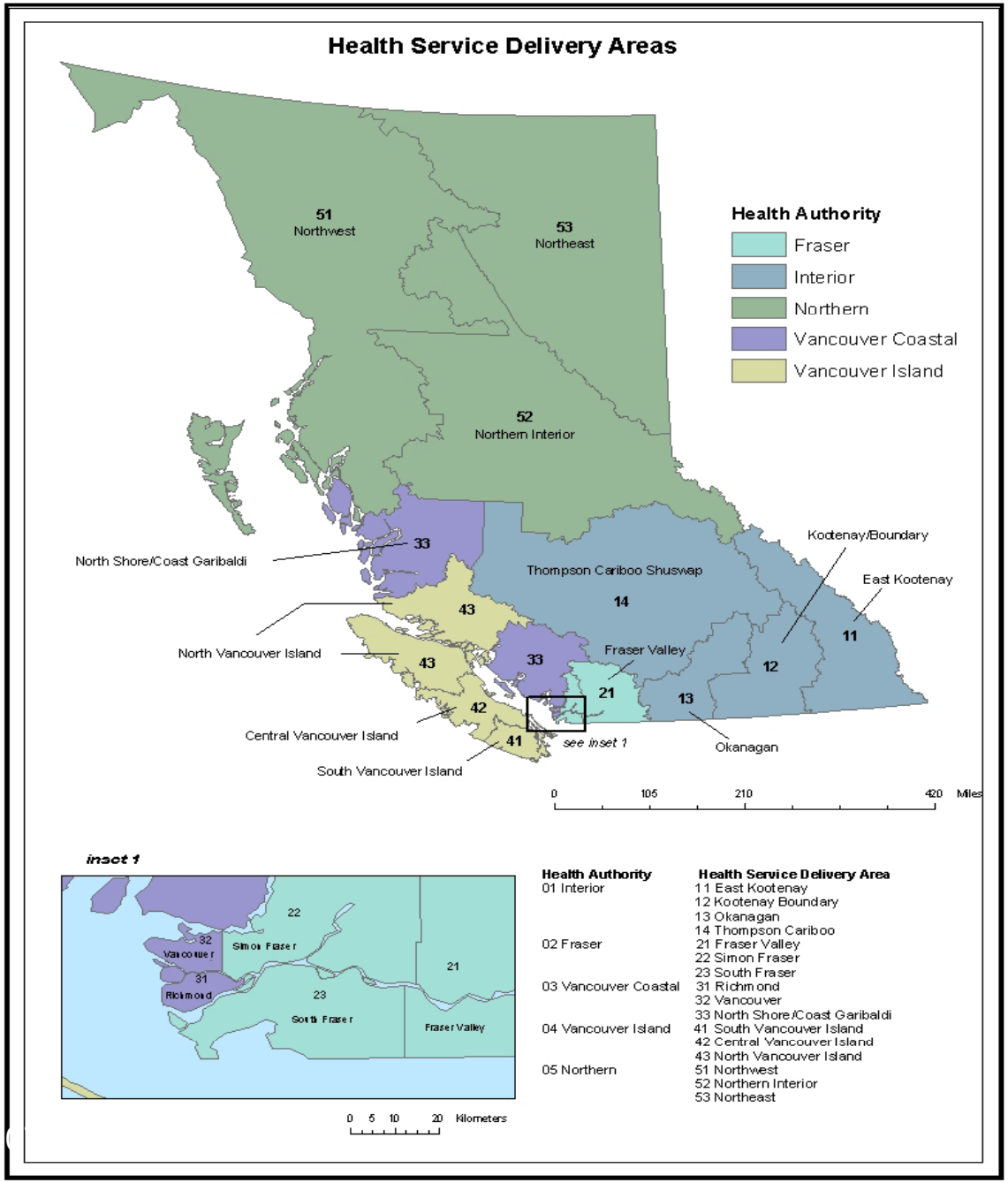
This study aims

- to develop a synthesis of analytic methods for a systematic burden of injury research framework that encompasses space-time surveillance monitoring, burden assessment, risk assessment, research dissemination and knowledge translation (priority setting in particular)

- to apply these methods to examine burden of injury mortality and disability in British Columbia (BC) and its local communities.

British Columbia Health Regions:

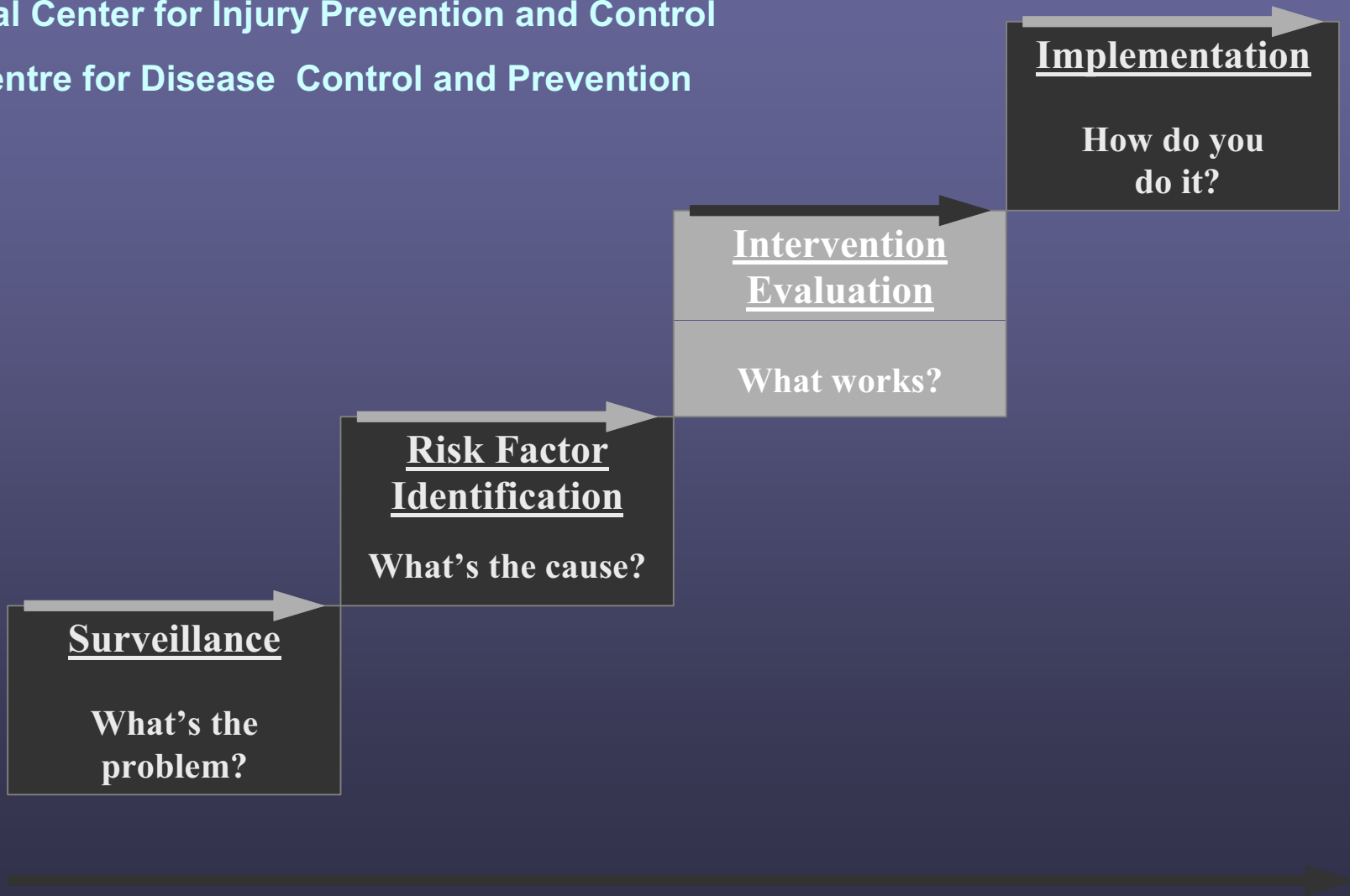
- *5 Health Authority Areas (HAs)*
- *16 Health Service Delivery Areas (HSDAs)*
- *84 Local Health Areas (LHAs)*


Health Service Delivery Areas
Health Authority
Fraser
Interior
Northern
Vancouver Coastal
Vancouver Island
51
Northwest
53
Northeast
52
Northern Interior
33
North Shore/Coast Garibaldi
43
North Vancouver Island
43
42
Central Vancouver Island
41
South Vancouver Island
Thompson Cariboo Shuswap
14
Kootenay/Boundary
East Kootenay
11
12
Fraser Valley
33
21
13
see inset 1
Okanagan
0 105 210 420 Miles
inset 1
22
Simon Fraser
32
Vancouver
31
Richmond
23
South Fraser
21
Fraser Valley
0 5 10 20 Kilometers
Health Authority
01 Interior
02 Fraser
03 Vancouver Coastal
04 Vancouver Island
05 Northern
Health Service Delivery Area
11 East Kootenay
12 Kootenay Boundary
13 Okanagan
14 Thompson Cariboo
21 Fraser Valley
22 Simon Fraser
23 South Fraser
31 Richmond
32 Vancouver
33 North Shore/Coast Garibaldi
41 South Vancouver Island
42 Central Vancouver Island
43 North Vancouver Island
51 Northwest
52 Northern Interior
53 Northeast

Public health approach to injury prevention and control

National Center for Injury Prevention and Control

U.S. Centre for Disease Control and Prevention



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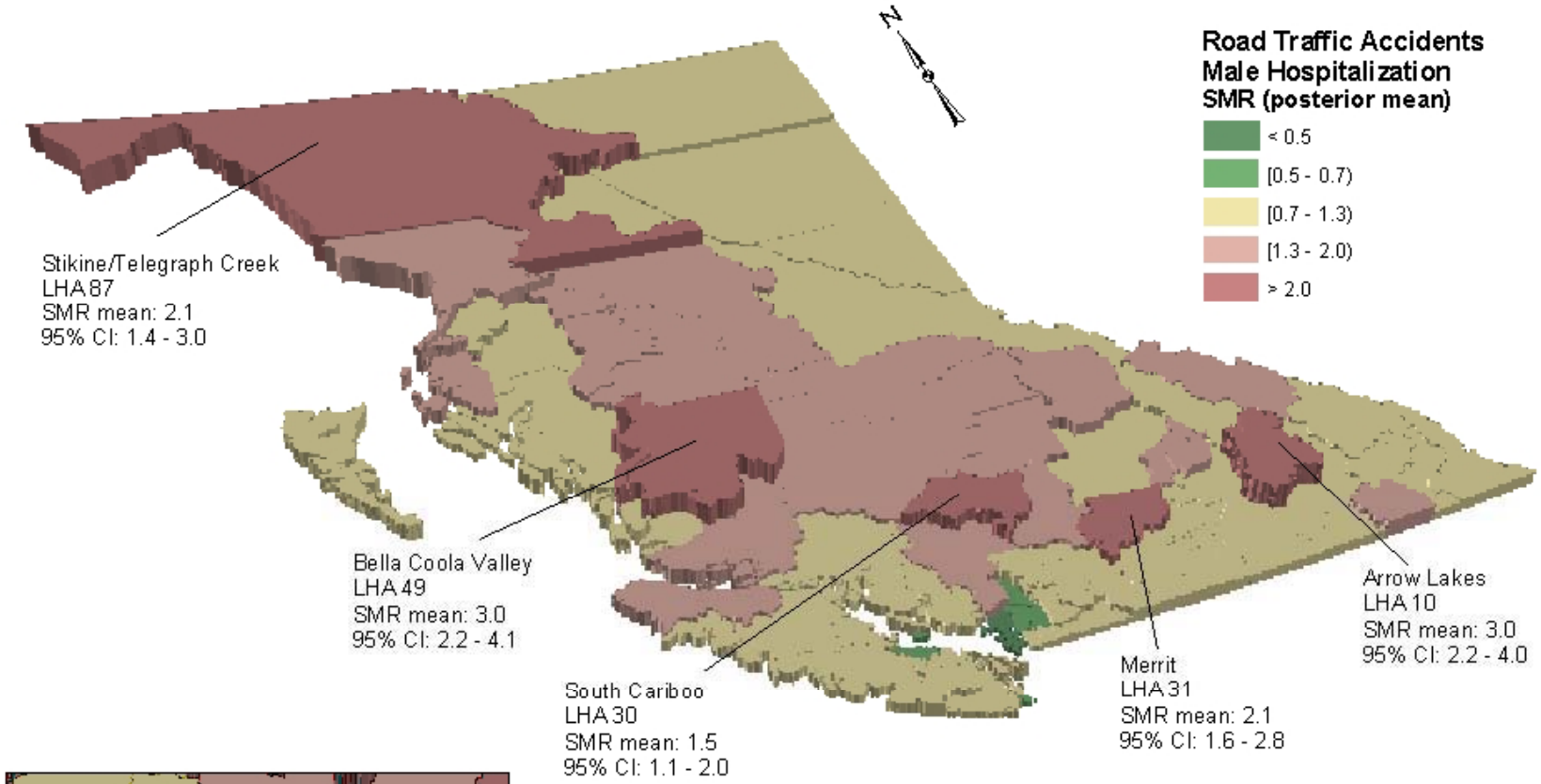
Spatial modeling

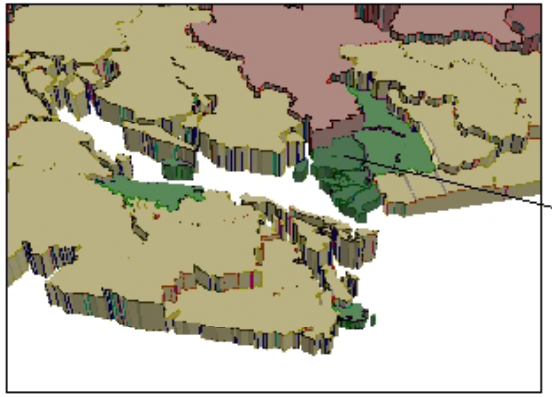
Ecological modeling

Spatio-temporal modeling

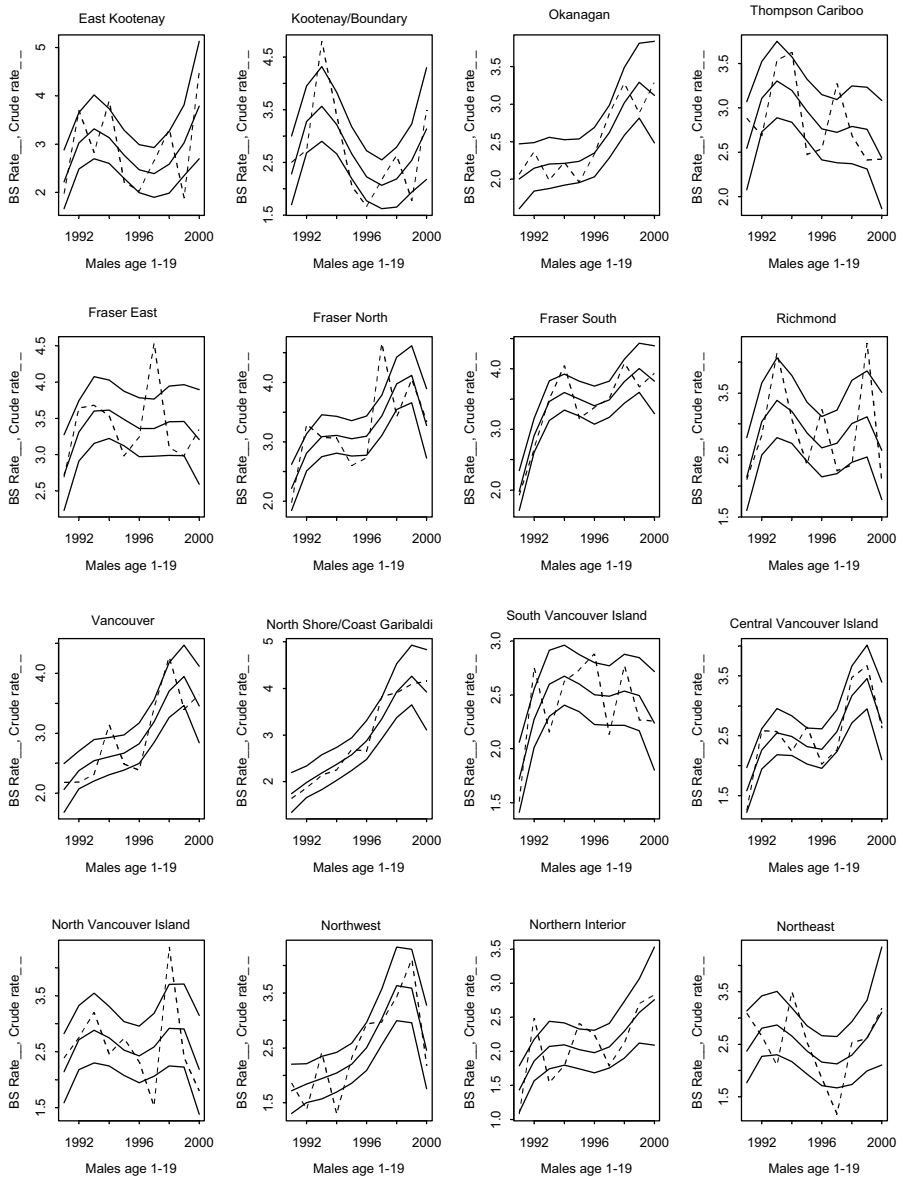
Small area disability adjusted life year

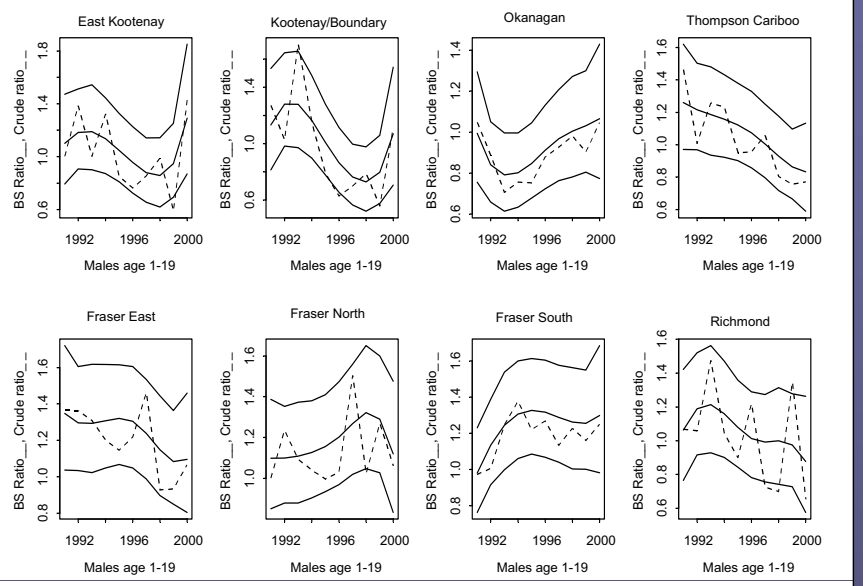
(Disease mapping methodology + Disability adjusted life year methodology)





Delta LHA 37 SMR mean: 0.4 / 95% CI: 0.3 - 0.6
Richmond LHA 38 SMR mean: 0.4 / 95% CI: 0.3 - 0.5
Burnaby LHA 41 SMR mean: 0.4 / 95% CI: 0.3 - 0.5
North Vancouver LHA 44 SMR mean: 0.4 / 95% CI: 0.3 - 0.5
West Vancouver - Bowen Island LHA 45 SMR mean: 0.4 / 95% CI: 0.3 - 0.6
Vancouver City Centre LHA 161 SMR mean: 0.4 / 95% CI: 0.3 - 0.5
Vancouver Westside LHA 164 SMR mean: 0.4 / 95% CI: 0.3 - 0.5
Vancouver South LHA 166 SMR mean: 0.4 / 95% CI: 0.3 - 0.5
Vancouver Downtown Eastside LHA 162 SMR mean: 0.4 / 95% CI: 0.3 - 0.6
Vancouver North East LHA 163 SMR mean: 0.4 / 95% CI: 0.3 - 0.5
Vancouver Midtown LHA 165 SMR mean: 0.4 / 95% CI: 0.3 - 0.5


East Kootenay
Kootenay/Boundary
Okanagan
Thompson Cariboo
Fraser East
Fraser North
Fraser South
Richmond
Vancouver
North Shore/Coast Garibaldi
South Vancouver Island
Central Vancouver Island
North Vancouver Island
Northwest
Northern Interior
Northeast
BS Rate__, Crude rate__
Males age 1-19
1992
1996
2000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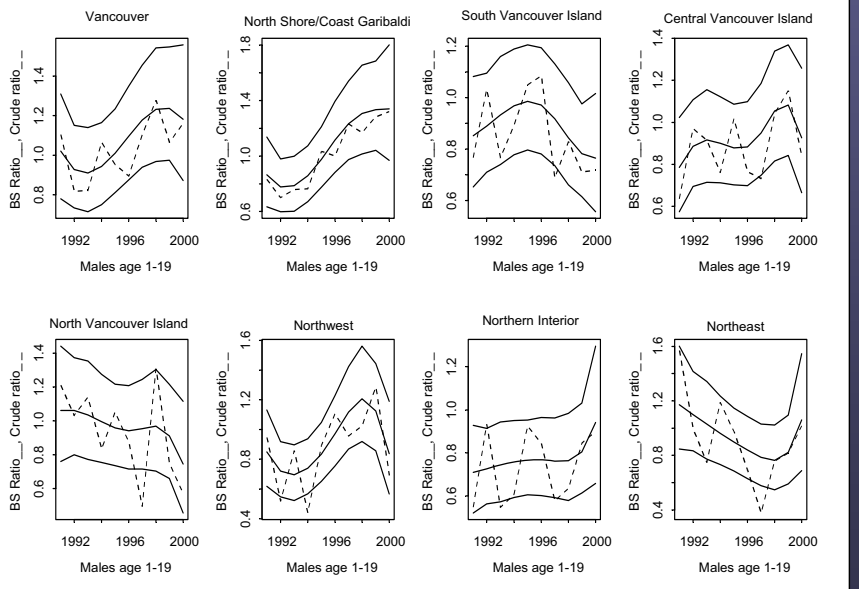
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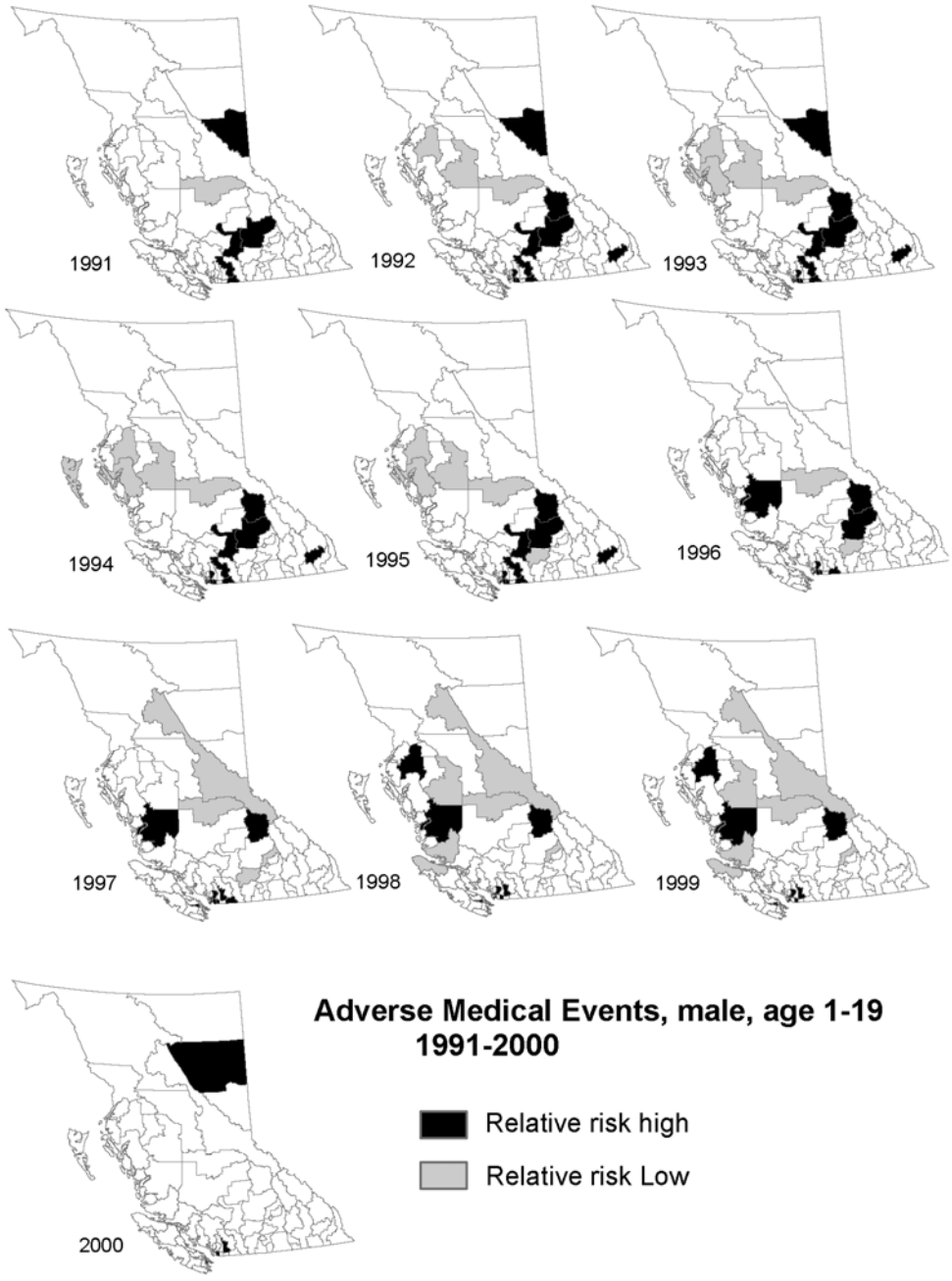
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
Adverse Medical Events, male, age 1-19
1991-2000
Relative risk high
Relative risk Low

The end