

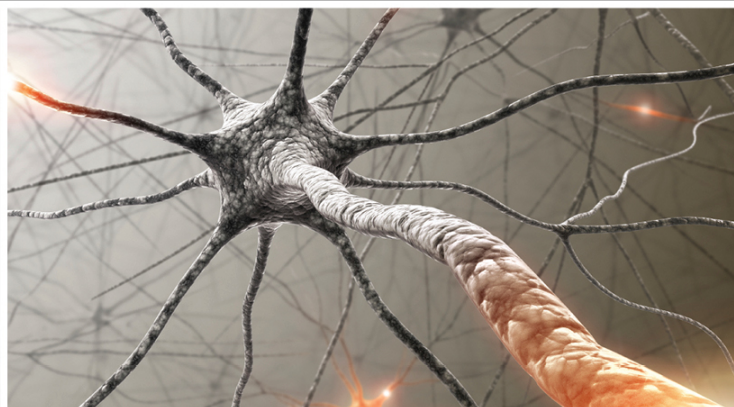
Estimating HIV Incidence at the National Level: example of Canada

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PROTECTING CANADIANS FROM ILLNESS



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Canada

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Purpose of national incidence estimates

- How many new HIV infections occurred in 2012?
- Estimates of HIV incidence support the development and evaluation of prevention programs
 - Best measure of overall state of the HIV epidemic
 - Can help target prevention activities, especially if estimates can be broken down by geographic area, risk group, age, gender, etc
- HIV incidence also important to help plan treatment and care services



Methods

- EPP-Spectrum (UNAIDS)
 - Not widely used in developed countries with case-based-surveillance systems
- Workbook method
- Incidence among those being tested for HIV
- Statistical modelling methods using data from case-based HIV/AIDS surveillance



Workbook Method

- Overview of method
 - Country divided into cells by geographic areas and by risk group (eg. injecting drug users in Toronto)
 - For each cell, estimated incidence in that risk group is multiplied by population size of that risk group
 - Incidence estimates are summed across all cells to get national estimate



Workbook Method

- Data needs are extensive
 - Large number of cells
 - Recent incidence estimate for each cell
 - Recent population size estimate for each cell (often this is even more difficult to obtain)
- Challenges
 - This approach is used as a minor method in Canada
 - Appears to produce an over-estimate in Canada (upper bound)
 - More relevant as a local method



Estimating incidence among those being tested for HIV

- Uses data from case-based HIV surveillance system
- Can examine persons testing more than once (repeat testers) or all persons being tested
- Repeat testers: data needs
 - Monitor both positive and negative test results
 - Track individuals at different testing episodes
 - Calculate incidence among the group of individuals who are repeat testers
- Limitations
 - incidence estimate applies to subset of persons testing repeatedly and not to the general population
 - results may be more useful in relative sense than an absolute sense



Estimating incidence among those being tested for HIV (continued)

- Incidence among all persons being tested for HIV
- Data needs
 - Monitor both positive and negative test results
 - An estimate of how recently persons testing positive were infected (recent infection lab assay or past test results)
 - Calculate incidence among the group of individuals who are tested
- Limitations
 - incidence estimate applies to subset persons who are being tested for HIV and not to the general population
 - results may be more useful in relative sense than an absolute sense
 - *NOTE:* with data on testing patterns and the calculation of weights to adjust for representativeness, this method turns into CDC method (provides number of new HIV infections, not an incidence rate)

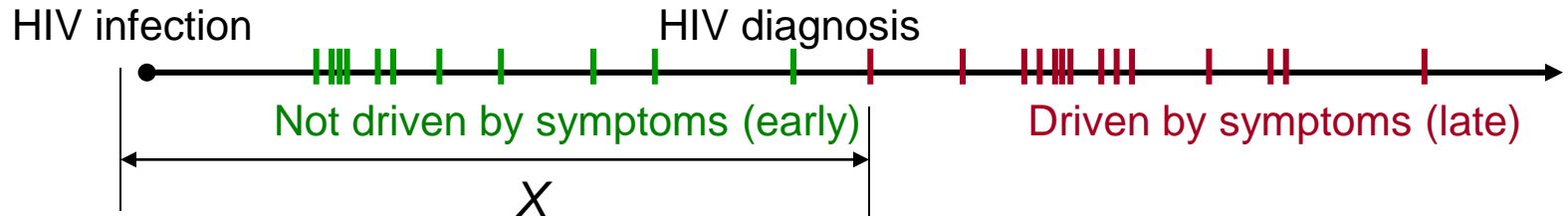


Statistical modelling

- Main method used to estimate HIV incidence in Canada
 - Other methods for corroboration/triangulation
- Outline of method
 - back-calculation method based on data from HIV case-based surveillance with additional data on the proportion of recent infections among newly diagnosed individuals
 - This is done by establishing an explicit link between the distribution of time-since-infection given being tested and the distribution of time-to-testing given being infected



Simplified description of model

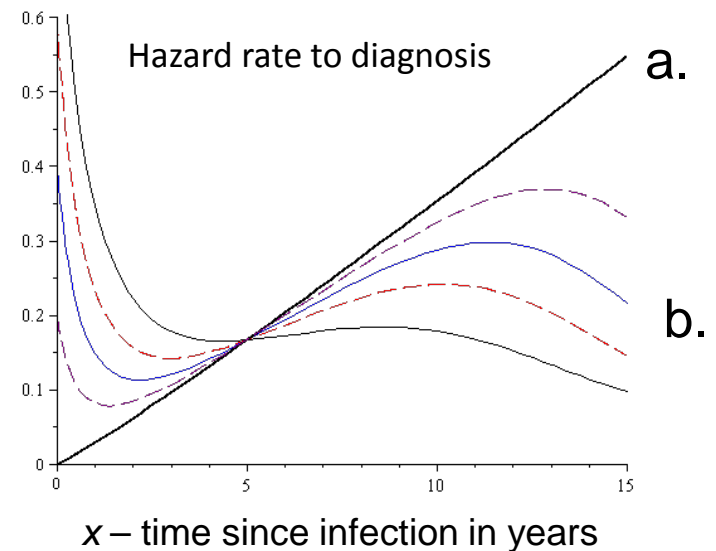


We consider two time scales: — time since infection: X
— calendar time when an infection occurs: t

We formulated a hazard rate function for the duration X between HIV infection to the first time when the infection is diagnosed.

The hazard functions in this method:

- If infected before or in 1985, HIV testing was not widely available. The rate to be diagnosed increases over time x driven by the internal force.
- The more recent the infection year, the higher a percentage of infected people tested not driven by symptoms. The hazard rate starts to show a “bathtub” pattern.



Convert these hazard functions into probability functions for calculation

$\Pr\{\text{HIV diagnosis at time } t + x \mid \text{infection at time } t\}$

Year at infection	Year of diagnosis																											Incidence estimate ↓
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	
1975	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
1979	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1980	7	6	6	5	4	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37
1981	41	43	42	38	33	27	21	16	11	8	5	3	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	292
1982	80	92	97	95	87	76	62	49	37	26	18	12	7	4	2	1	1	0	0	0	0	0	0	0	0	0	0	746
1983	70	91	105	110	107	99	86	71	55	41	29	20	13	8	5	3	2	1	0	0	0	0	0	0	0	0	0	916
1984	31	51	66	77	80	79	72	63	52	40	30	22	15	10	6	4	2	1	1	0	0	0	0	0	0	0	0	702
1985	7	22	37	48	55	58	57	52	45	37	29	22	15	11	7	4	3	1	1	0	0	0	0	0	0	0	0	511
1986		17	24	35	44	50	53	51	47	41	34	26	20	14	10	6	4	2	1	1	0	0	0	0	0	0	0	480
1987			195	68	38	27	22	19	16	14	12	10	8	6	5	4	3	2	2	1	1	1	1	1	1	1	1	459
1988				158	55	30	21	16	14	12	10	8	7	6	4	3	3	2	2	1	1	1	1	1	1	1	1	359
1989					105	37	20	14	11	9	8	7	6	5	4	3	2	2	1	1	1	1	1	1	1	0	0	239
1990						77	27	15	10	8	7	6	5	4	3	3	2	2	1	1	1	1	1	1	0	0	0	174
1991							68	24	13	9	7	6	5	4	4	3	2	2	1	1	1	1	1	1	0	0	0	152
1992								61	21	12	8	6	5	5	4	3	3	2	2	1	1	1	1	1	1	0	0	137
1993									50	17	10	7	5	4	4	3	3	2	2	1	1	1	1	1	1	0	0	112
1994										39	14	8	5	4	3	3	2	2	2	1	1	1	1	1	1	0	0	87
1995											30	10	6	4	3	3	2	2	2	1	1	1	1	1	1	0	0	67
1996												27	9	5	4	3	2	2	2	1	1	1	1	1	1	0	0	59
1997													29	10	6	4	3	3	2	2	2	1	1	1	1	1	0	65
1998														35	12	7	5	4	3	3	2	2	2	1	1	1	1	79
1999															44	15	8	6	5	4	3	3	2	2	2	1	1	96
2000																58	20	11	8	6	5	4	4	3	3	2	2	126
2001																	68	24	13	9	7	6	5	4	4	3	2	145
2002																		73	25	14	10	8	6	5	4	3	2	153
2003																			78	27	15	10	8	7	6	5	4	160
2004																				81	28	16	11	8	7	6	5	162
2005																					79	27	15	10	8	7	6	152
2006																						76	26	14	10	8	7	141
2007																							77	27	15	10	8	137
2008																								76	26	14	10	126
2009																									69	24	13	106
2010																										70	24	94
2011																											78	182



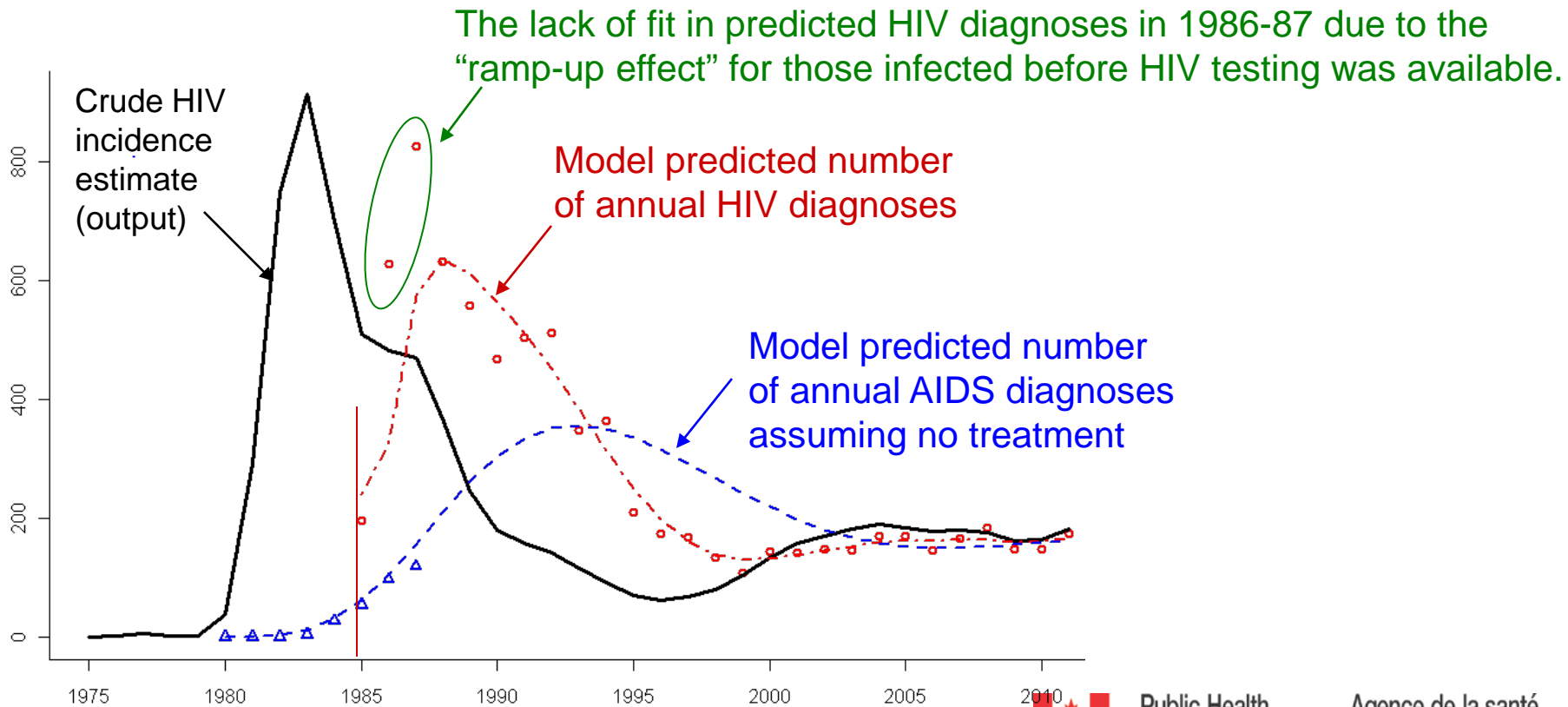
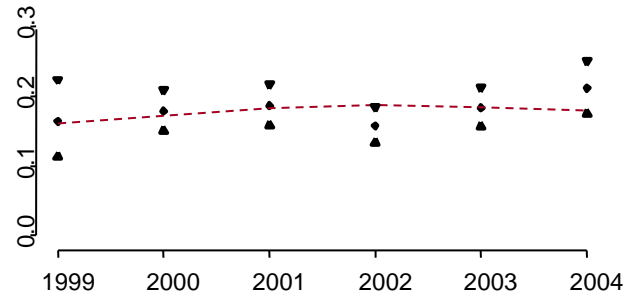
Canadian statistical modelling method

- Data needs
 - Annual counts of newly diagnosed HIV cases from case-based surveillance
 - Estimate of the proportion of new diagnoses that were recently infected
 - Recent infection lab testing algorithm
 - History of recent negative HIV test
 - Diagnosis of primary HIV infection
 - Annual counts of newly diagnosed AIDS cases



Sample input and output

Estimated HIV incidence also predicts % of recent infections among new HIV diagnoses with confidence limits

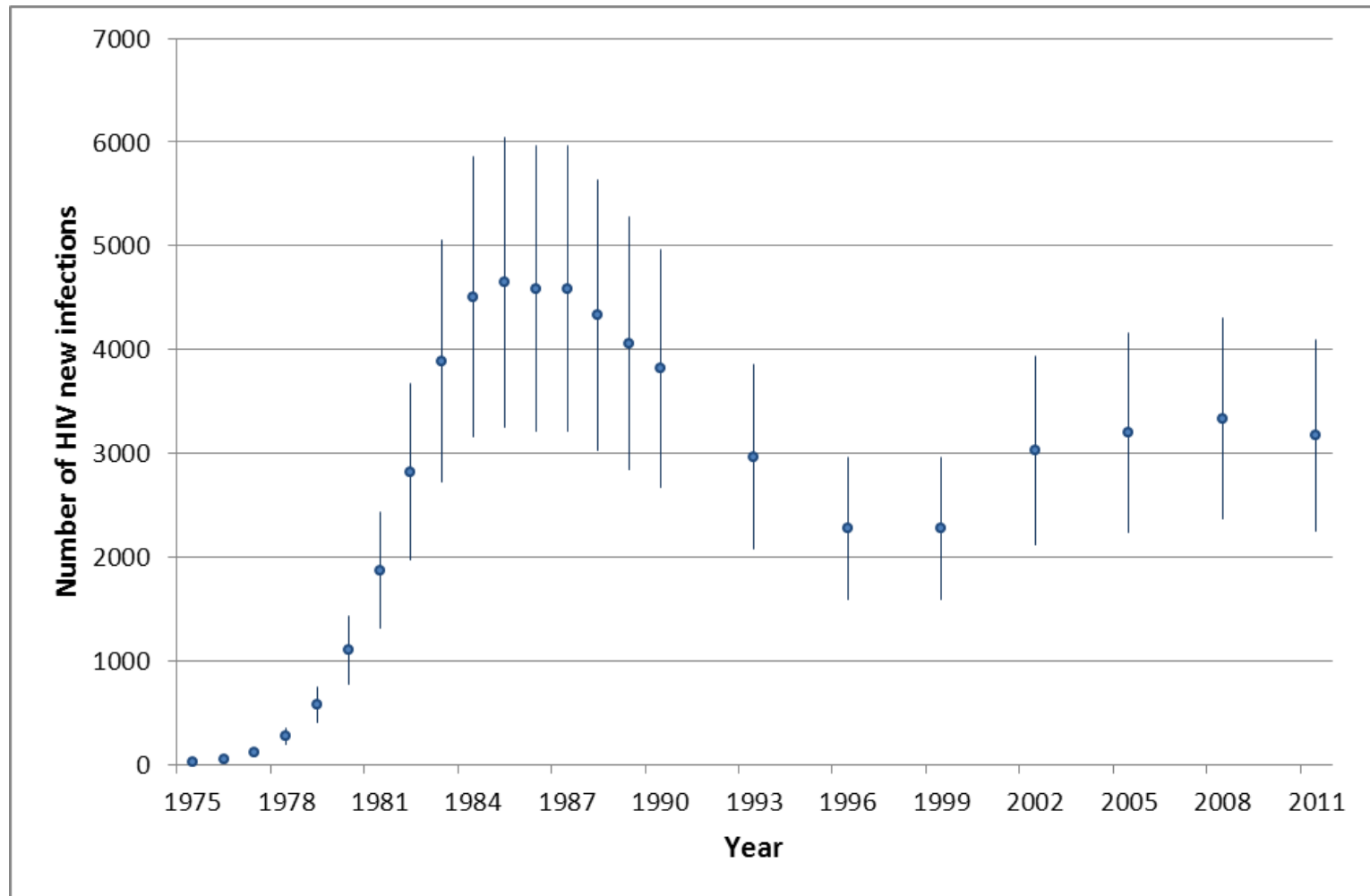


Canadian statistical modelling method

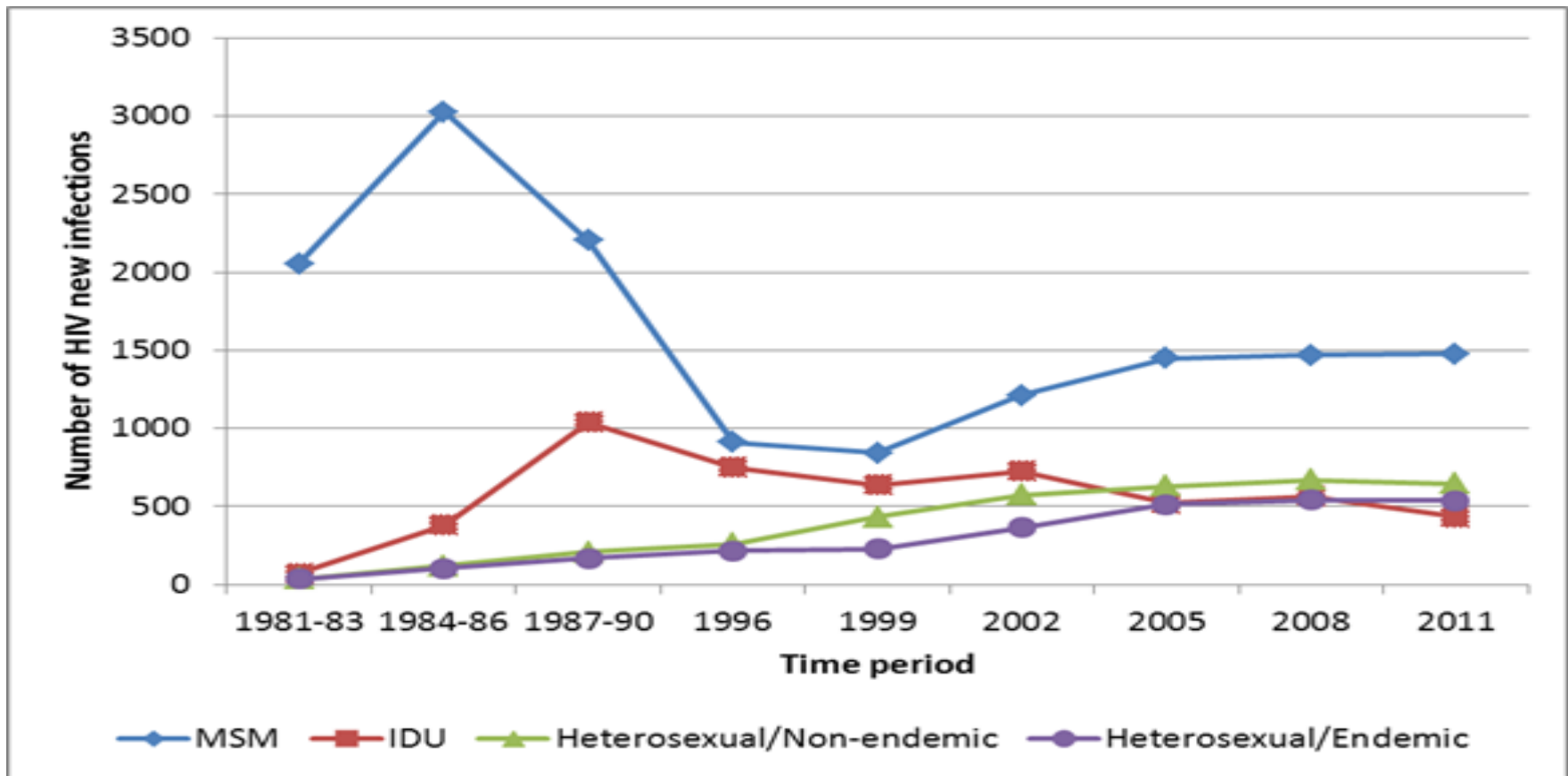
- Limitations
 - Depends on completeness of AIDS and especially of HIV surveillance data
 - Depends on representativeness of surveillance data (do some groups have less access to HIV testing?)
 - Needs estimate of recency from at least a subset of HIV diagnoses.
 - Appears to underestimate incidence (perhaps since method assumes every HIV case is eventually diagnosed)
 - Most uncertain in recent years (very dependent on recent trends in HIV surveillance data)



Estimated number of new HIV infections in Canada by year (point estimate and range of uncertainty)



Estimated number of new infections among various risk groups, by time period (ranges of uncertainty omitted)

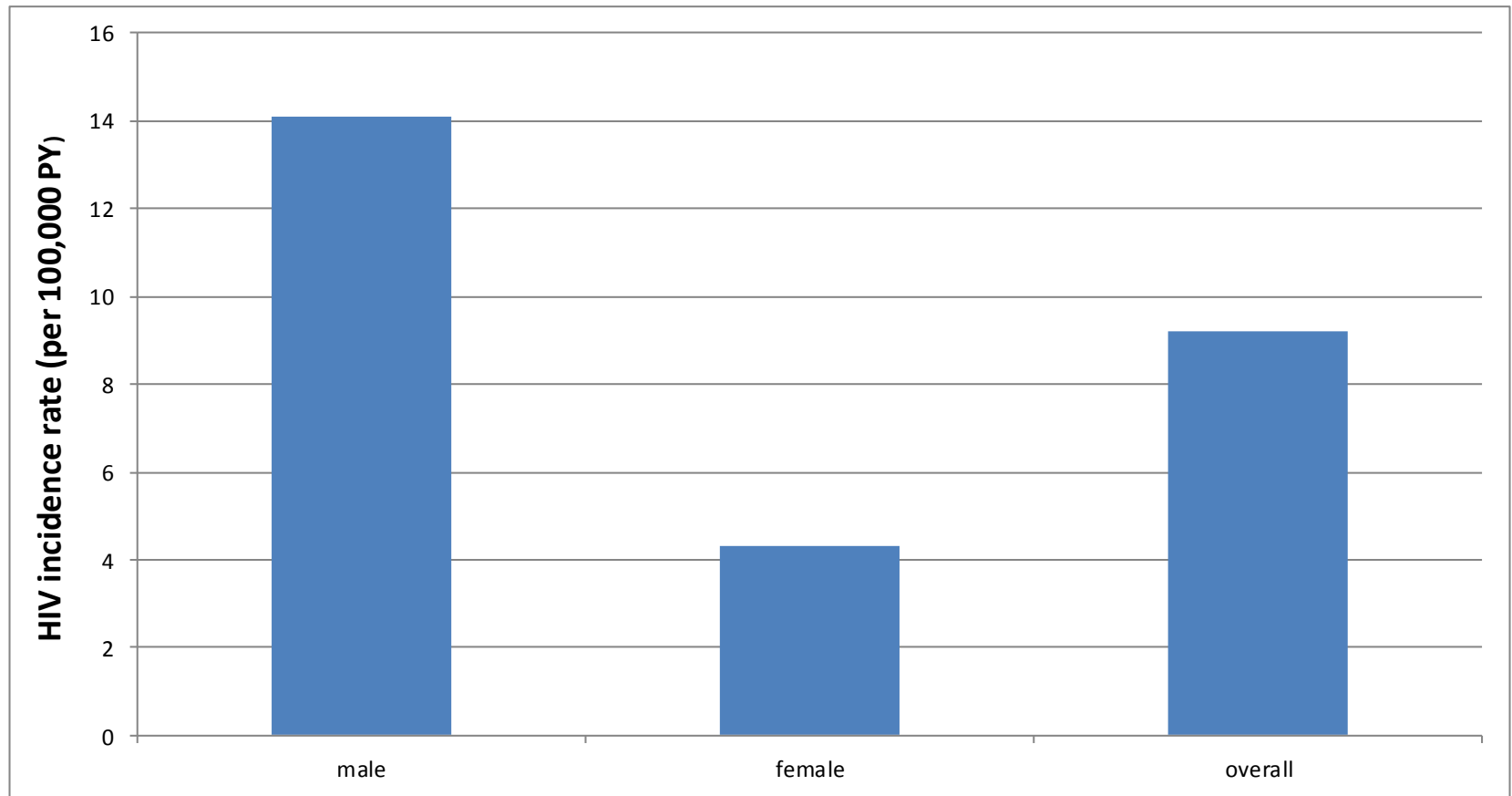


Estimated number of new HIV infections in Canada, 2011 and 2008

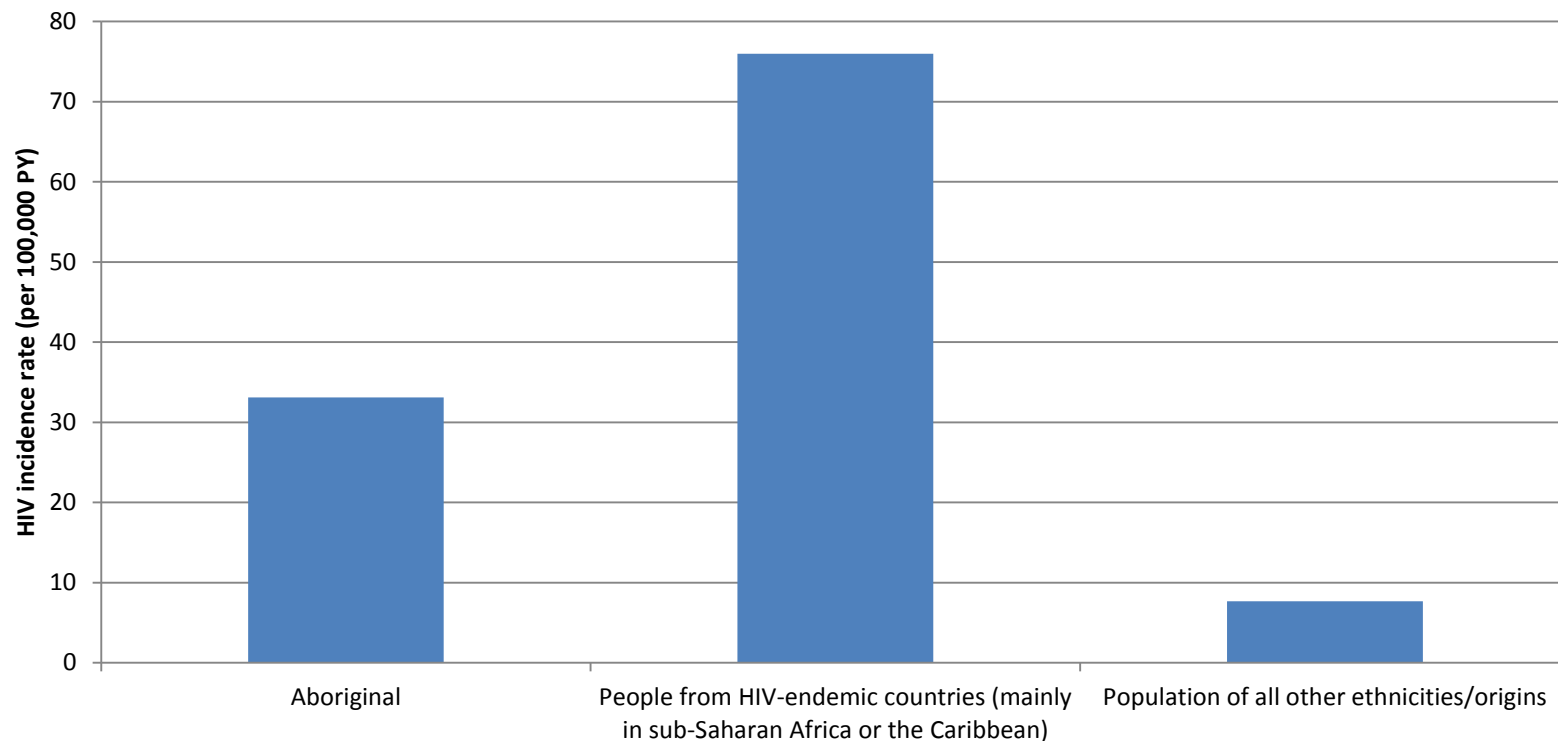
Year	MSM	MSM-IDU	IDU	Heterosexual/ Non-endemic	Heterosexual/ Endemic	Other	Total
2011	1480 (1060-1900)	80 (50-110)	435 (300-570)	645 (450-840)	535 (370-700)	<20	3175 (2250-4100)
%	46.6%	2.5%	13.7%	20.3%	16.9%		
2008	1470 (1040-1900)	90 (50-130)	565 (400-730)	670 (470-870)	540 (380-700)	<20	3335 (2370-4300)
%	44.1%	2.7%	16.9%	20.1%	16.2%		



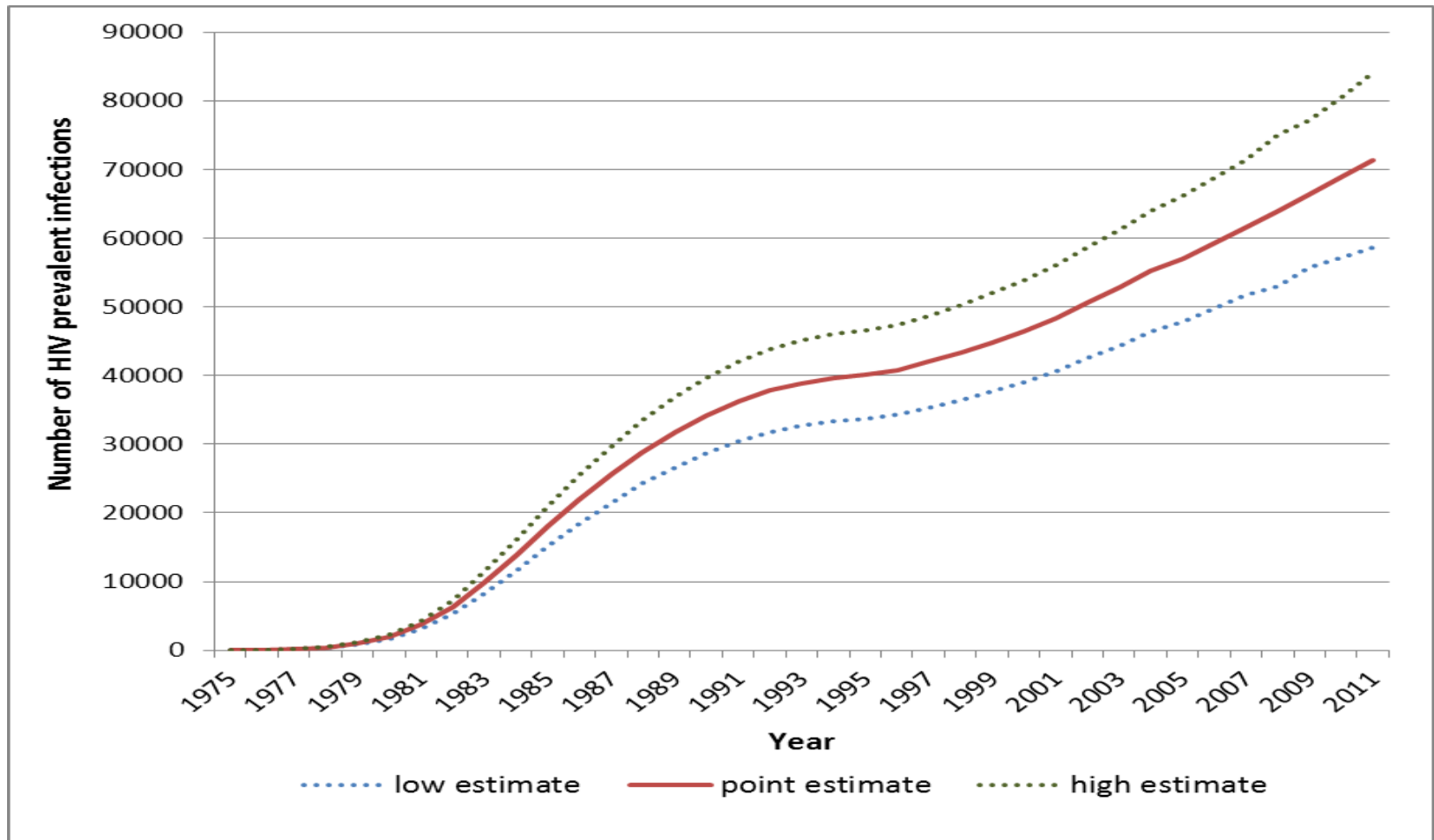
Estimated HIV incidence rate by sex, Canada, 2011



Estimated HIV incidence rate by ethnicity or country of birth, Canada, 2011



Estimated HIV prevalence over time in Canada (cumulative incidence minus mortality)



References for Canadian method

- Yan P, Zhang F, Wand, H. Using HIV Diagnostic Data to Estimate HIV Incidence: Method and Simulation. *Statistical Communications in Infectious Diseases* 2011: Vol. 3 (1), Article 6.
 - source code available on request (R computing language)
- Yang Q, Boulos D, Yan P, Zhang F, Remis RS, Schanzer D, Archibald CP. Estimates of the number of prevalent and incident human immunodeficiency virus (HIV) infections in Canada, 2008. *Can J Public Health* 2010;101(6):486-90.
- Wand H, Wilson D, Yan P, Gonnermann A, McDonald A, Kaldor J, Law M. Characterizing trends in HIV infection among men who have sex with men in Australia by birth cohorts: Results from a modified back-projection method. *J Int AIDS Soc* 2009;12(1):19.



Summary

- Statistical modelling method is main method used to estimate HIV incidence in Canada
- Other methods and sources of data are used for corroboration and triangulation
- National HIV incidence estimates are uncertain and all countries are looking for ways to improve the methodology

