The impact of pharmaceutical innovation on the burden of disease in Canada, 2000-2016

Frank R. Lichtenberg

frank.lichtenberg@columbia.edu

Columbia University

and

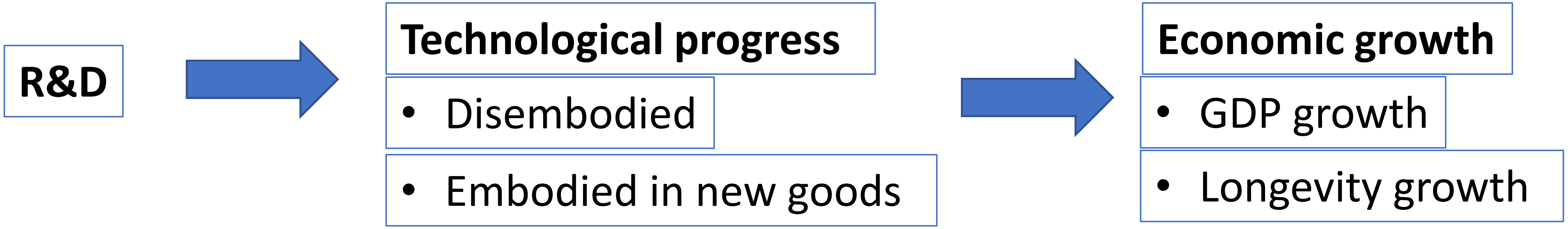
National Bureau of Economic Research

Financial support for this research was provided by Merck Canada Inc.

The longevity of Canadians has increased during the 21st century, despite some adverse trends

- Life expectancy at birth increased from 79.24 years in 2000 to 82.14 years in 2015.
- The age-standardized rate of potential years of life lost before age 75 per 100,000 population declined from 4214 during 1999-2003 to 3601 during 2009-2013—a 15% decline.
- Longevity has increased, despite rising obesity
  - Between 2003 and 2014, the fraction of Canadian men whose reported height and weight classified them as obese increased from 16.0% to 21.8%; the fraction of Canadian women whose reported height and weight classified them as obese increased from 14.5% to 18.7%.

R&D, technological progress, and economic growth



Nordhaus (2005): “To a first approximation, the economic value of increases in longevity in the last hundred years is about as large as the value of measured growth in non-health goods and services.”

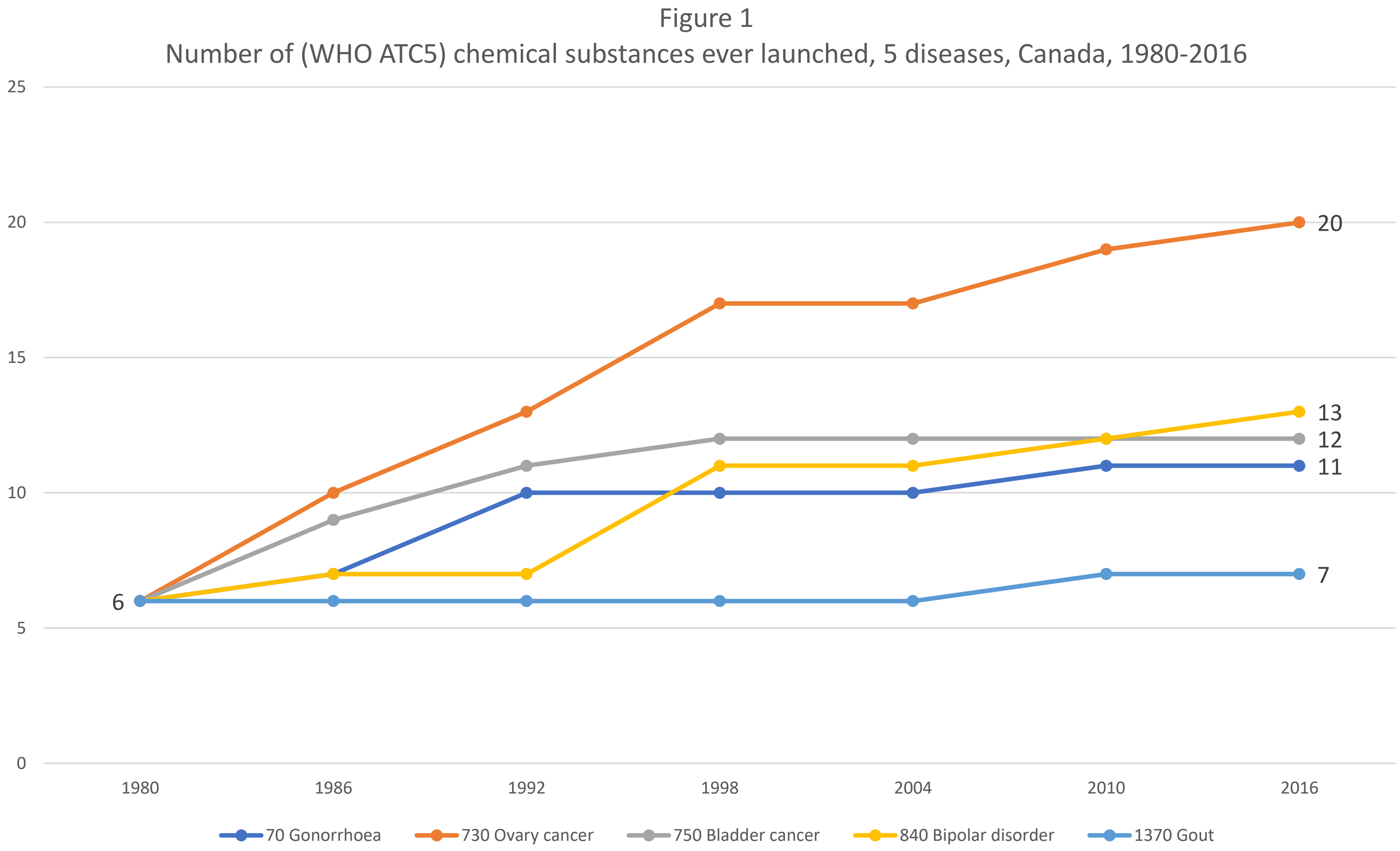
Romer (1990): “growth…is driven by technological change…”

Hercowitz (1998): “‘embodiment’ is the main transmission mechanism of technological progress to economic growth” (p. 223).

Jones (1998): “technological progress is driven by research and development (R&D) in the advanced world”;
NSF: the medical substances and devices sector is the most R&D-intensive major industrial sector in the U.S.;
Dorsey et al (2010): 88% of privately-funded U.S. biomedical research expenditure was funded by pharmaceutical and biotechnology firms; the remaining 11% was funded by medical device firms.

Study objectives and methods

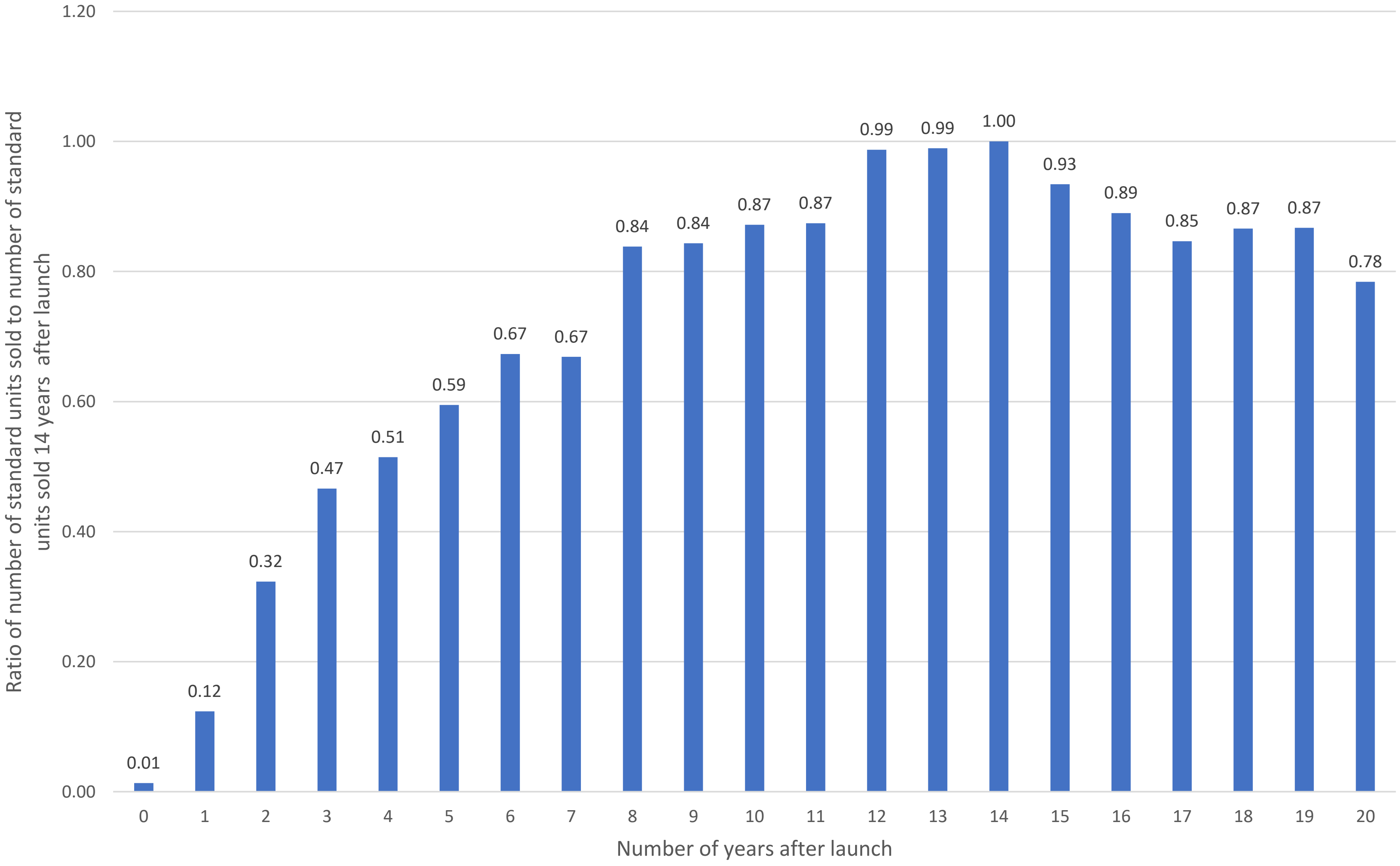
- We perform an econometric assessment of the role that pharmaceutical innovation—the introduction and use of new drugs—has played in reducing the burden of disease in Canada, by investigating whether diseases for which more new drugs were launched had larger subsequent reductions in disease burden.
- Since utilization of a drug reaches a peak about 12-14 years after it was launched, we allow for considerable lags in the relationship between new drug launches and the burden of disease.



Source: Author's calculations based on data contained in Health Canada Drug Product Database and Thériaque database.

14 new drugs for treating ovary cancer; only 6 new drugs for treating bladder cancer.

Figure 2
Drug age-utilization profile



Source: Author's calculations based on data contained in Health Canada Drug Product Database and IQVIA MIDAS database.

Outcome measures

- We analyze the impact of new drug launches on a comprehensive measure of disease burden—the age-standardized disability-adjusted life-years lost (DALY) rate—and on its two components: the age-standardized years of life lost (YLL) and years lost to disability (YLD) rates.
- We also analyze the impact of new drug launches on the number of hospital discharges and on the average length of hospital stays.

Fixed-effects model

$$\ln(Y_{ct}) = \beta_k \ln(CUM\_DRUG_{c,t-k}) + \alpha_c + \delta_t + \varepsilon_{ct}$$

where Y_{ct} is one of the following variables:

$DALY_{ct}$	= the age-standardized rate of DALYs lost due to cause c in year t (t = 2000, 2016)
YLL_{ct}	= the age-standardized rate of years of life lost due to cause c in year t
YLD_{ct}	= the age-standardized rate of years of healthy life lost due to disability due to cause c in year t

and

$CUM\_DRUG_{c,t-k}$	= $\sum_m IND_{mc} LAUNCHED_{m,t-k}$ = the number of chemical substances to treat medical condition c that had been launched in Canada by the end of year t-k (k = 0, 1, 2,…,20)
IND_{mc}	= 1 if chemical substance m is used to treat (indicated for) medical condition c = 0 if chemical substance m is not used to treat (indicated for) medical condition c
$LAUNCHED_{m,t-k}$	= 1 if chemical substance m had been launched in Canada by the end of year t-k = 0 if chemical substance m had not been launched in Canada by the end of year t-k
α_c	= a fixed effect for medical condition c
δ_t	= a fixed effect for year t

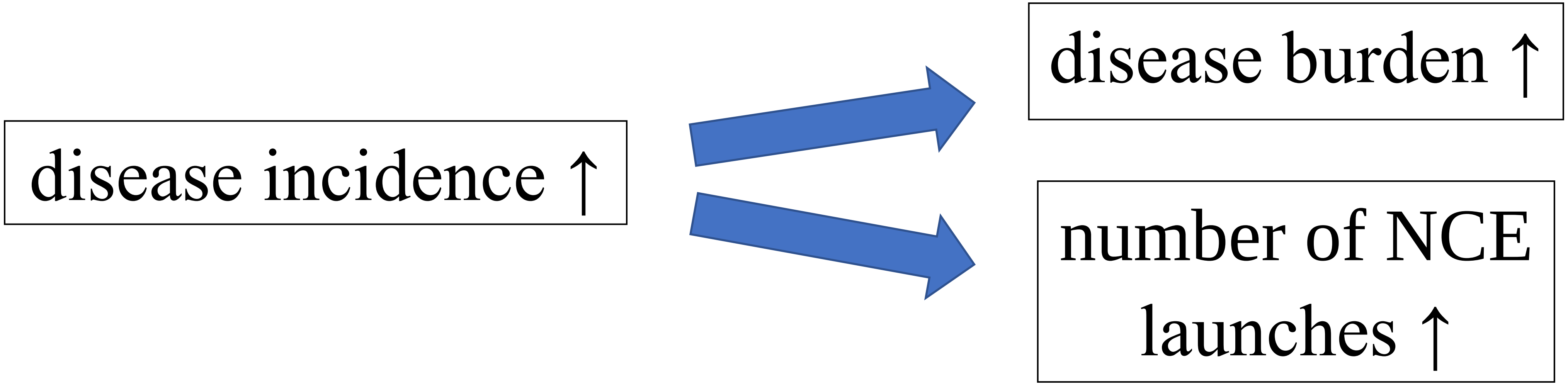
Long-difference model

$$\Delta \ln(Y_c) = \beta_k \, \Delta \ln(CUM\_DRUG\_k_c) + \delta' + \varepsilon_c'$$

where

$\Delta \ln(Y_c)$	$= \ln(Y_{c,2016} / Y_{c,2000})$
$\Delta \ln(CUM\_DRUG\_k_c)$	$= \ln(CUM\_DRUG_{c,2016-k} / CUM\_DRUG_{c,2000-k})$
δ'	$= (\delta_{2016} - \delta_{2000})$
ε_c'	$= (\varepsilon_{c,2016} - \varepsilon_{c,2000})$

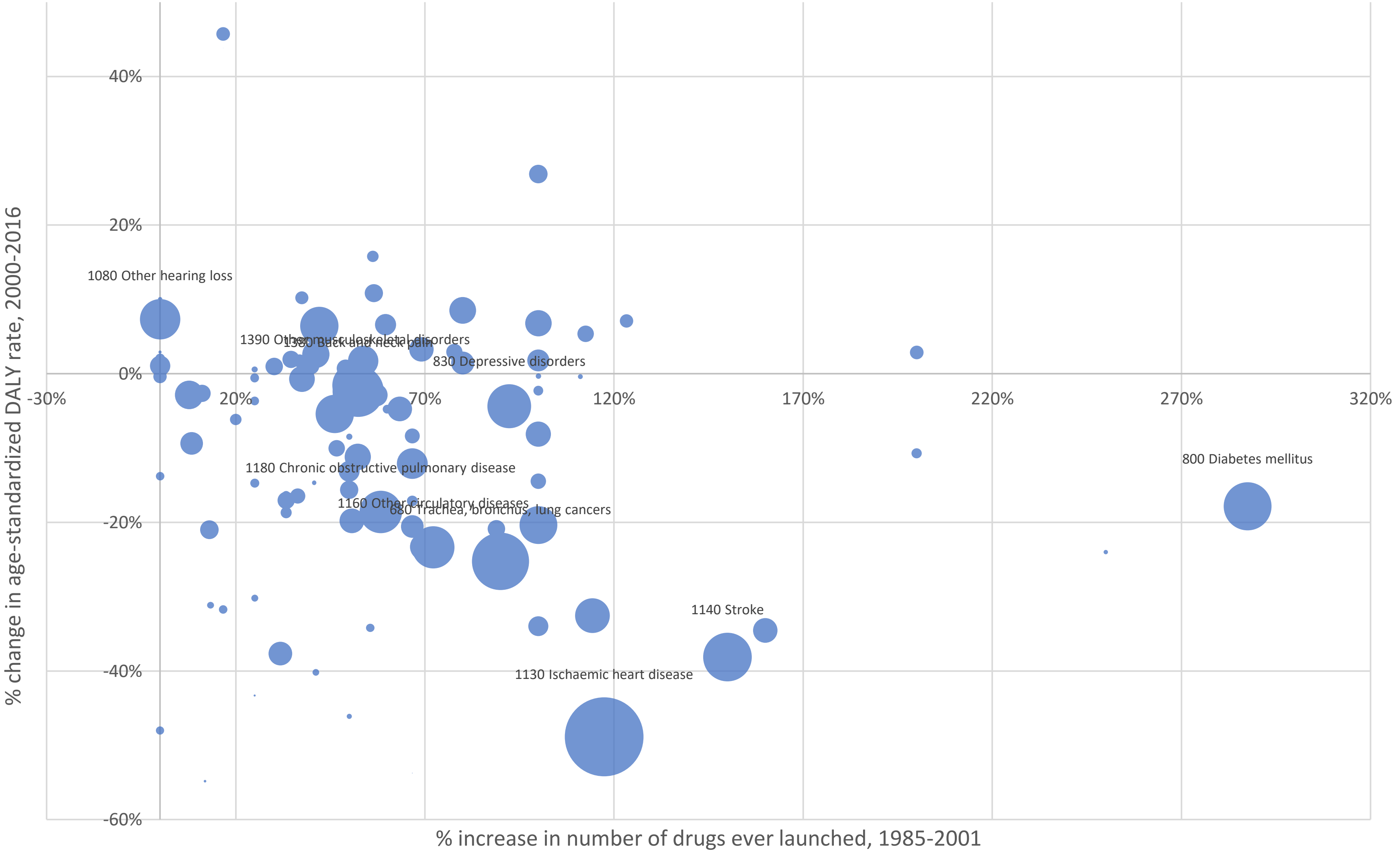
Higher disease incidence is likely to result in both higher disease burden and a larger number of chemical substance launches



Findings

- The number of DALYs lost is significantly inversely related to the number of drugs that had ever been launched 9-20 years earlier, and the number of YLLs is significantly inversely related to the number of drugs that had ever been launched 11-20 years earlier.
- The launch of a drug has the largest (most negative) impact on the number of DALYs and YLLs 15 years after it was launched.

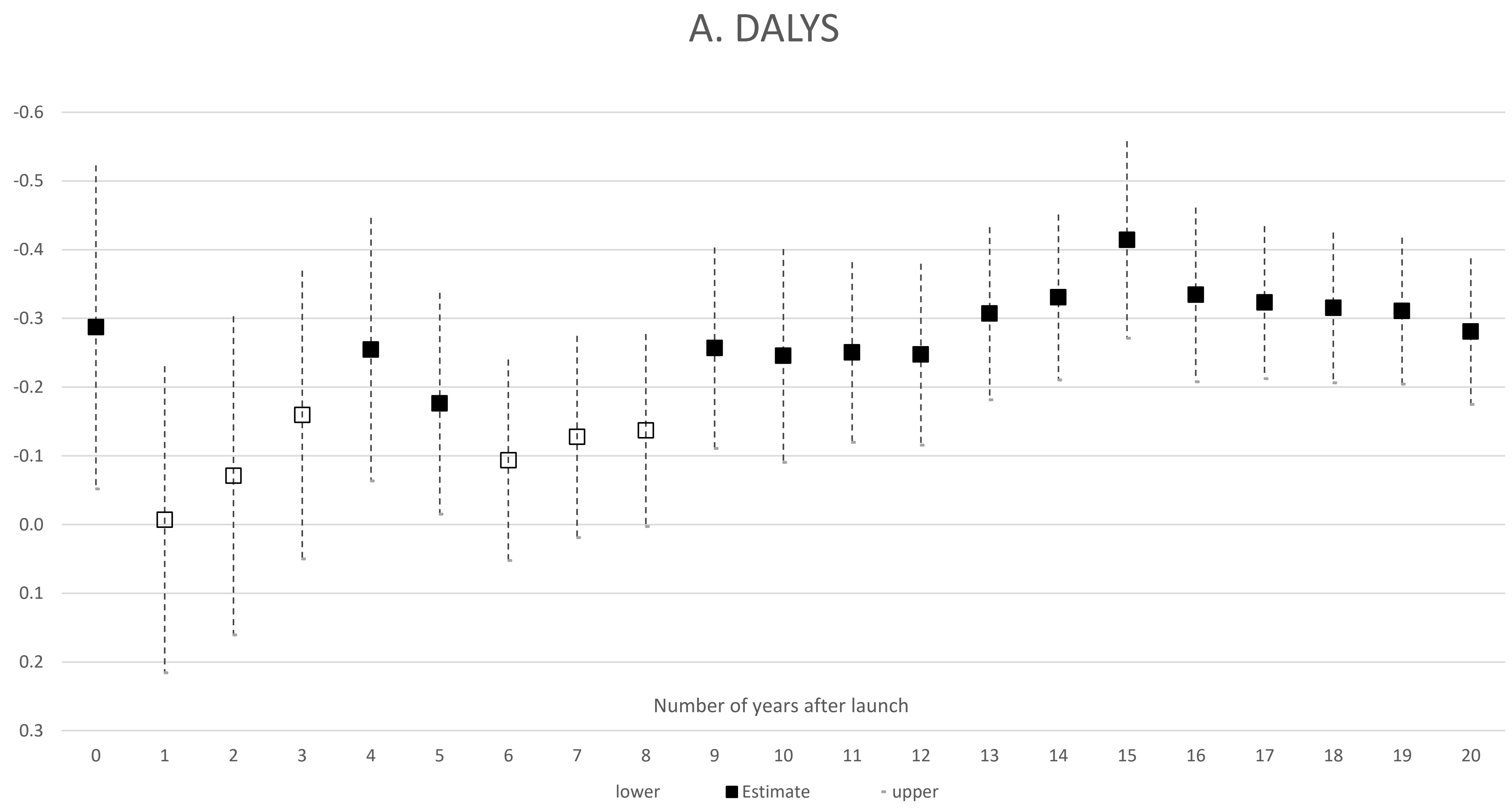
Relationship across diseases between % increase in number of drugs ever launched, 1985-2001,
and % change in age-standardized DALY rate, 2000-2016



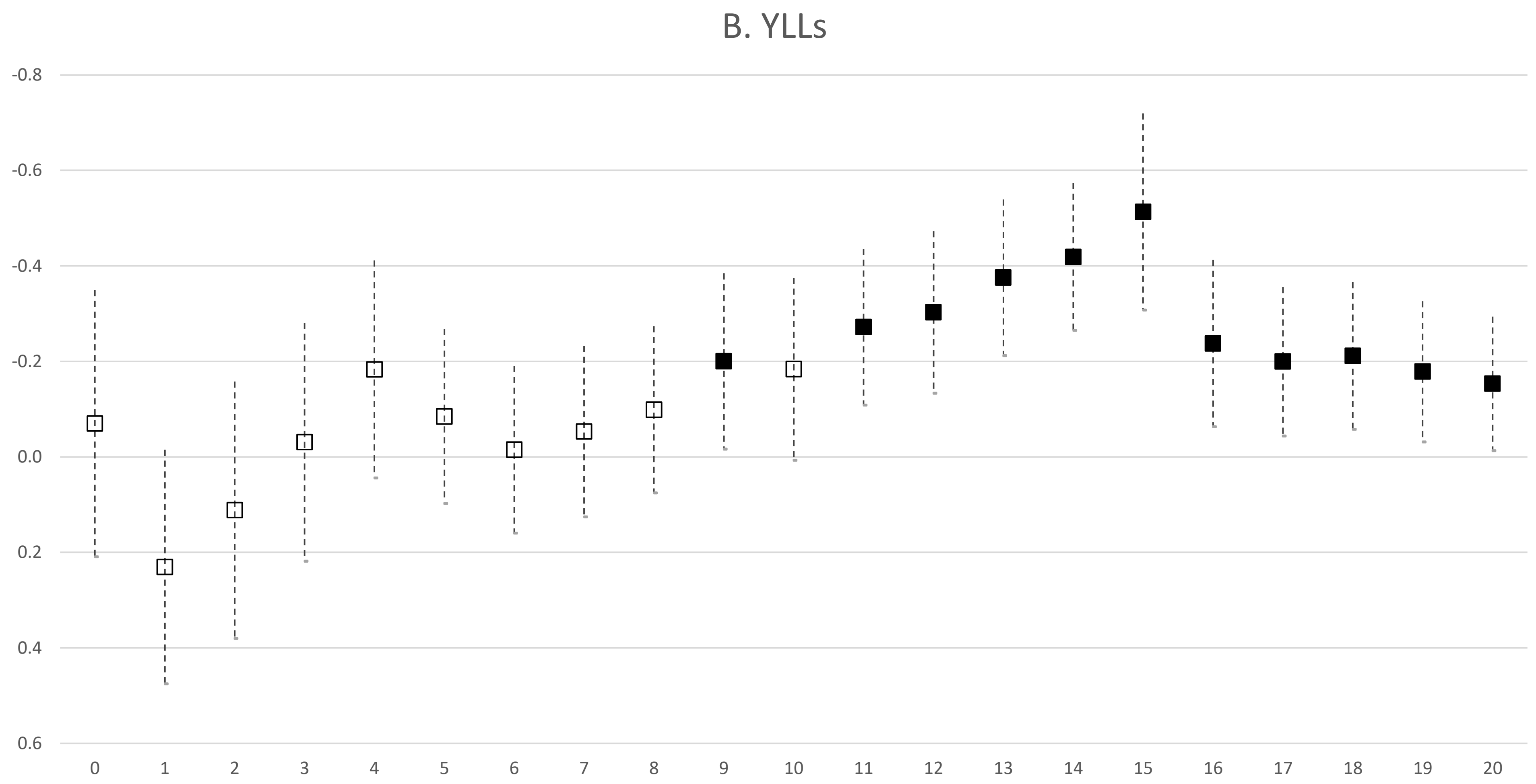
Bubble area is proportional to $(DALY_{c,2000} + DALY_{c,2016})/2$.

- The estimates indicate that if no drugs had been launched during 1986-2001, the age-standardized DALY rate would not have declined between 2000 and 2016; it might even have increased.
- Almost all (93%) of the reduction in DALYs was due to a reduction in YLL.
- The estimates imply that new drug launches during 1986-2001:
  - reduced DALYs in 2016 by 21%
  - reduced YLLs in 2016 by 28%
  - reduced YLDs in 2016 by 3%

Estimates of β_k parameters of eq. (4)



Estimates of β_k parameters of eq. (4)



The number of YLLs is significantly inversely related to the number of drugs that had ever been launched 11-20 years earlier.
The launch of a drug has the largest (most negative) impact on the number of DALYs and YLLs 15 years after it was launched.

Comparison of relative utilization and β_k estimate profiles

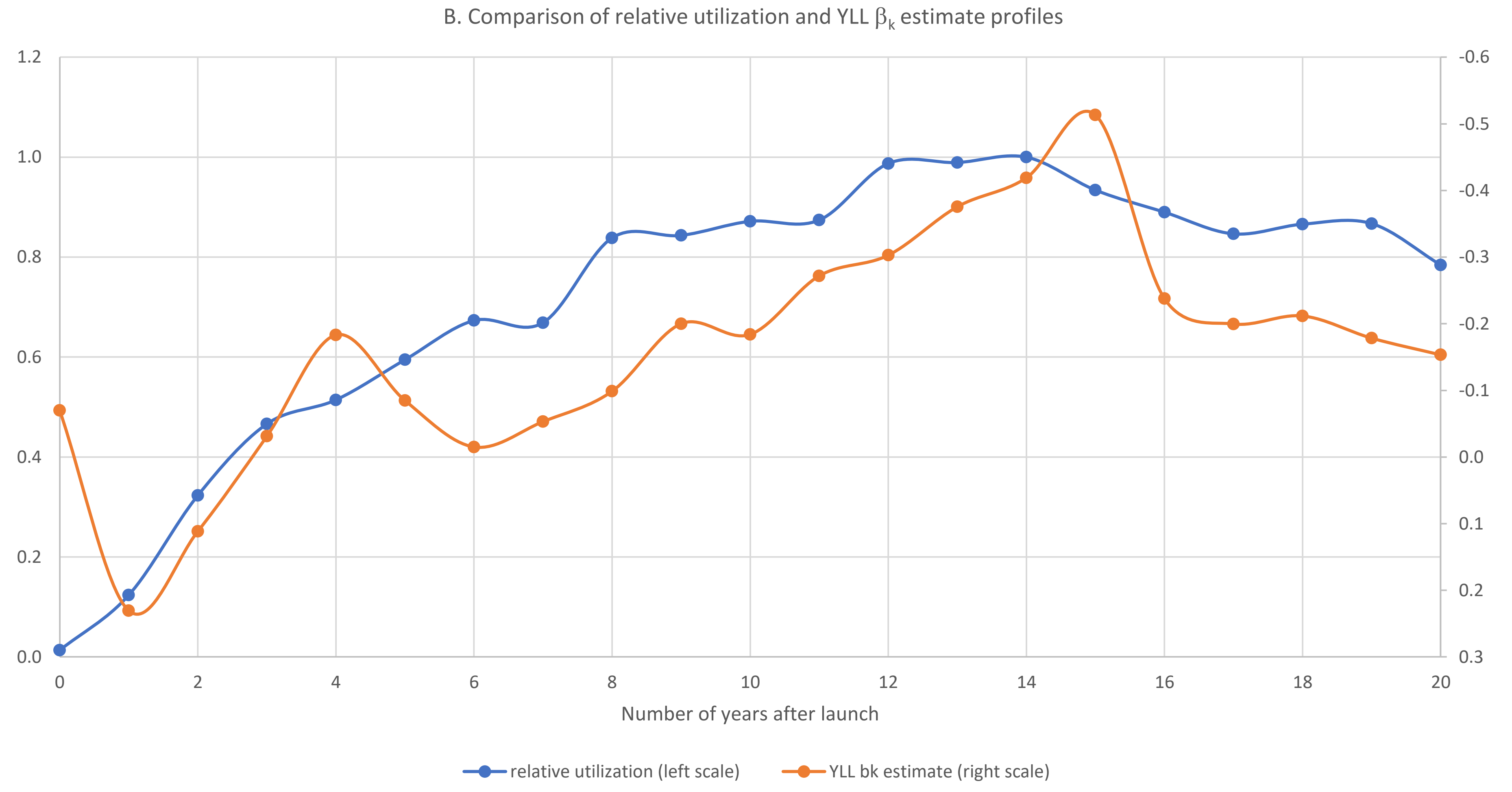
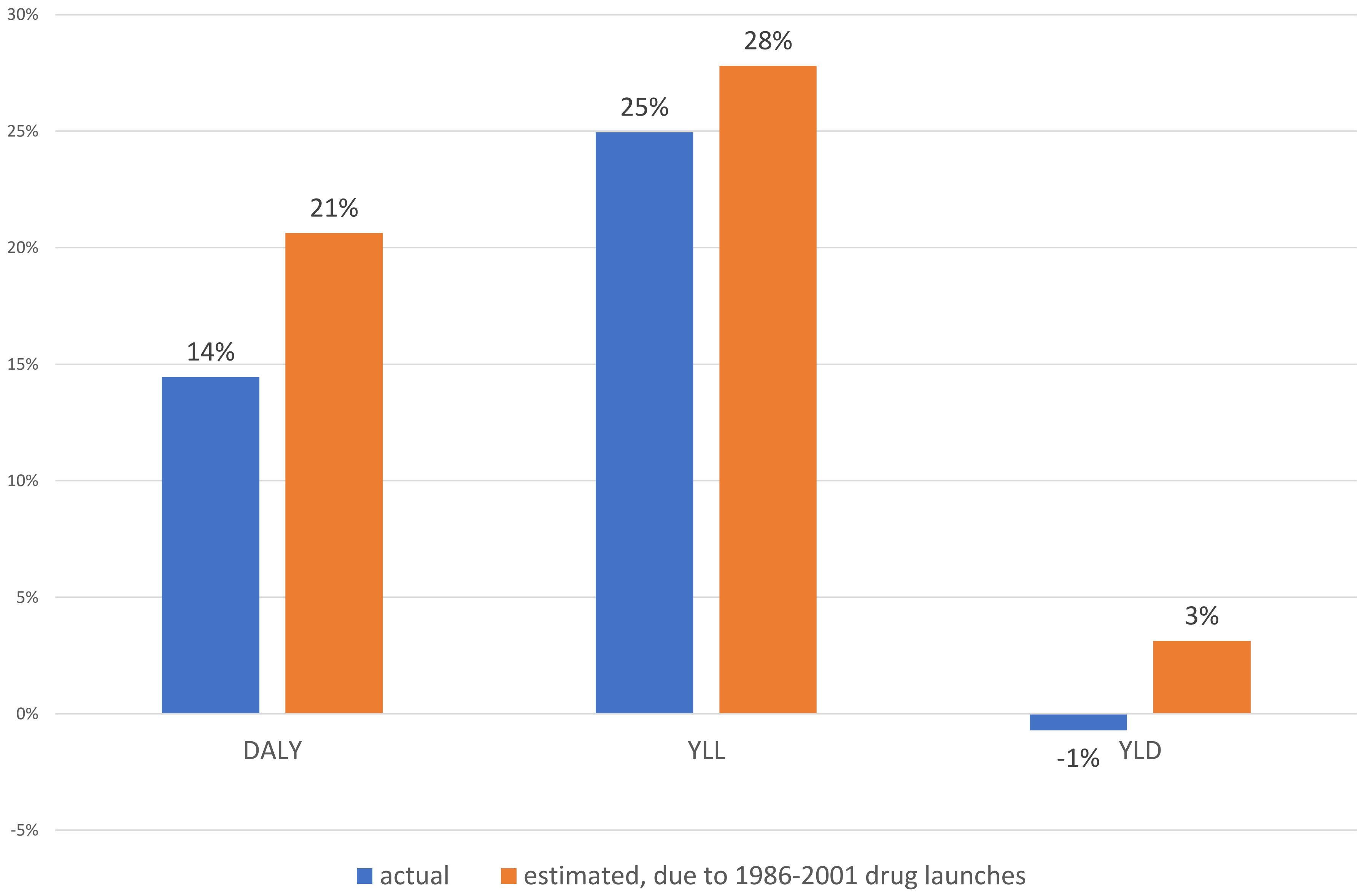


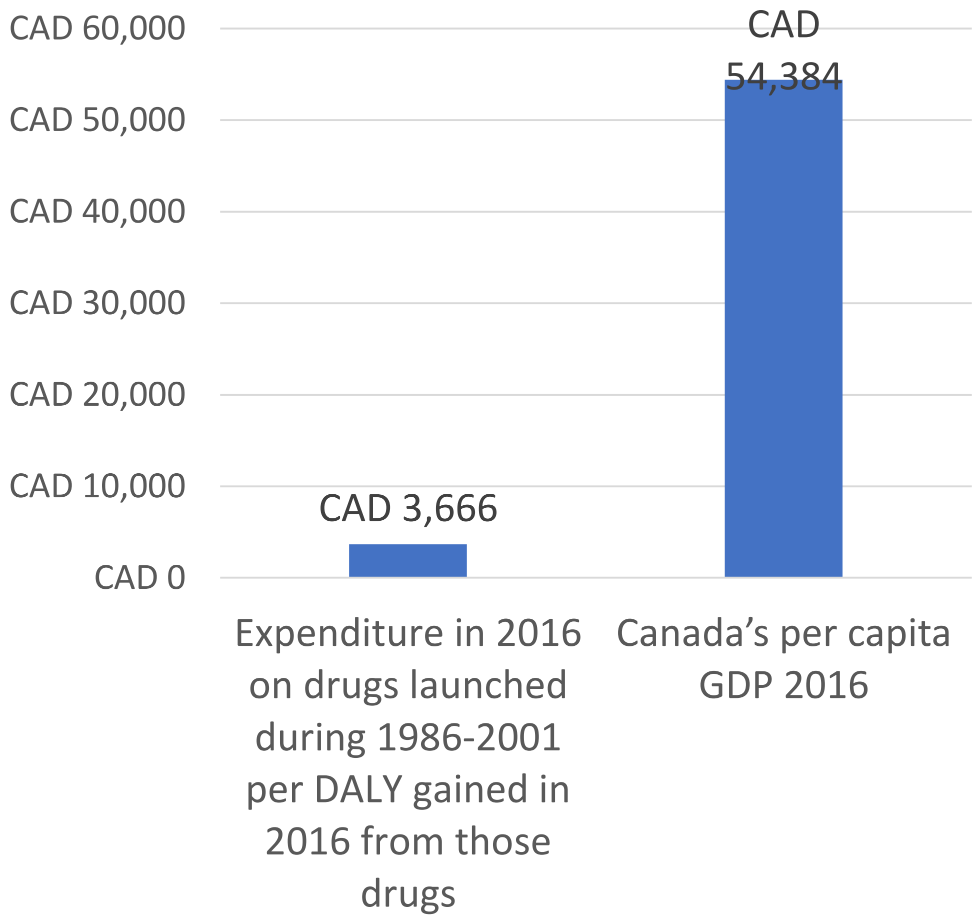
Figure 6

Actual vs. estimated % declines in age-standardized DALY, YLL, and YLD rates, 2000-2016



Cost-effectiveness

- We estimate that drugs launched during 1986-2001 reduced the number of DALYs lost in 2016 by 2.31 million.
- Expenditure in 2016 on drugs launched during 1986-2001 per DALY gained in 2016 from those drugs was 3666 CAD.
- Interventions that avert one DALY for less than average per capita income for a given country or region are generally considered to be very cost–effective; Canada's per capita GDP was 54,384 CAD in 2016, so our estimates indicate that the new drugs launched during 1986-2001 were very cost–effective, overall.

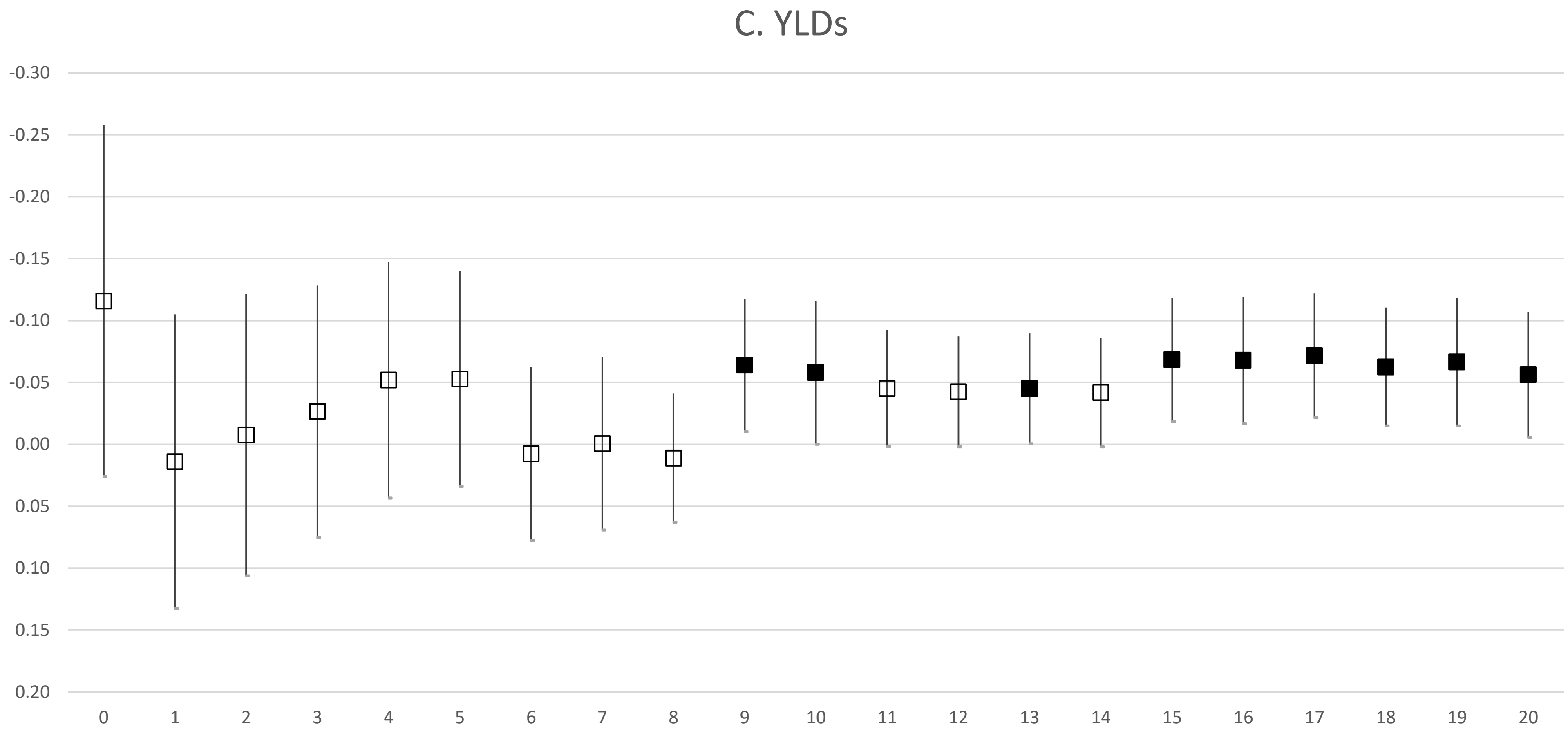


New drugs reduced length of hospital stays

- Our estimates also indicate that, if no drugs had been launched during 1986-2001, the average length of 2016 hospital stays would have been about 16% higher.
- The reduction in hospital expenditure due to shorter average length of stay may have been larger than the expenditure on the drugs responsible for shorter hospital stays.

Additional slides

Estimates of β_k parameters of eq. (4)



Comparison of relative utilization and β_k estimate profiles