The impact of pharmaceutical innovation on cancer mortality in Mexico, 1998-2014

Frank R. Lichtenberg

frl1@columbia.edu

Columbia University and

National Bureau of Economic Research

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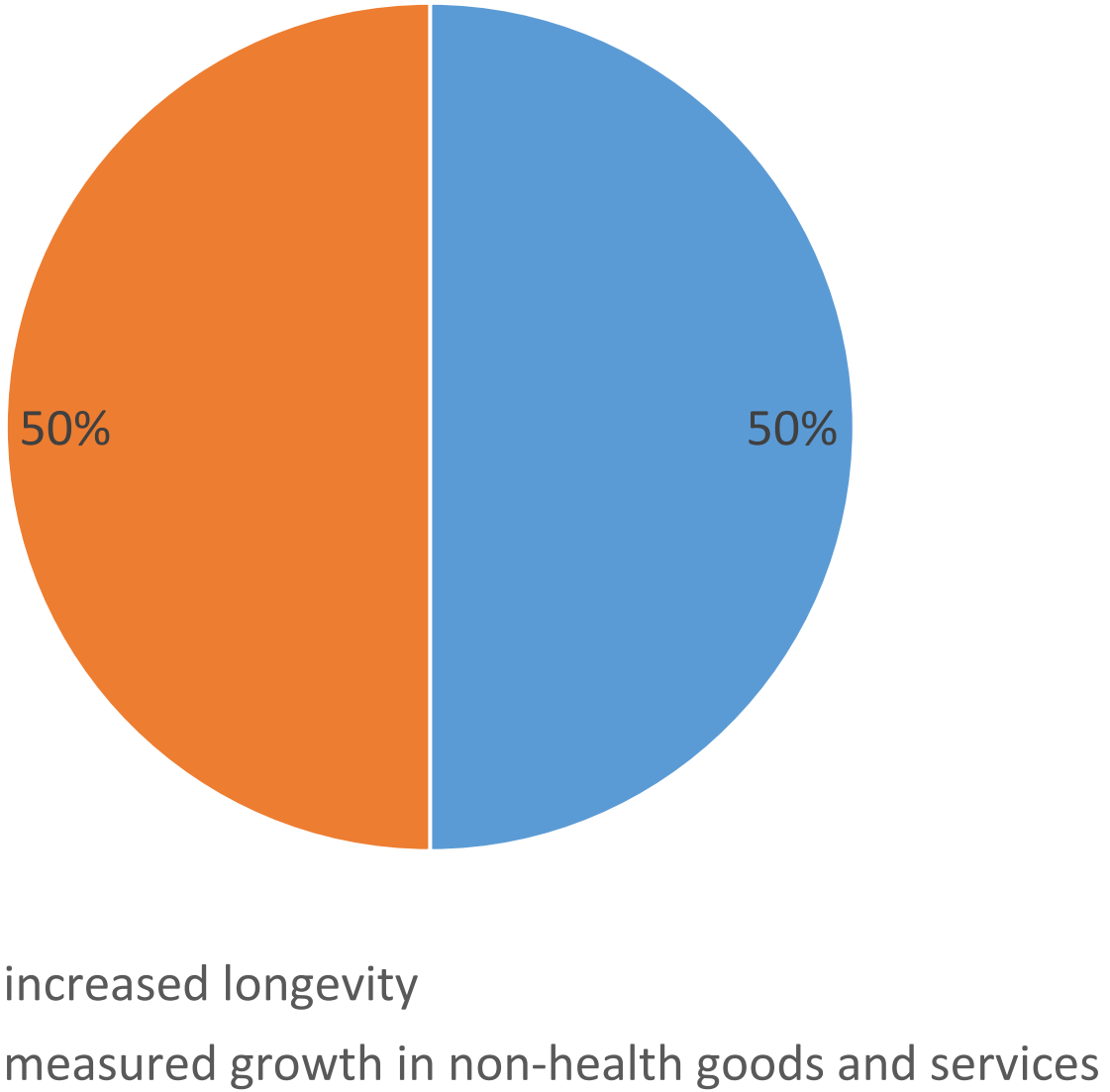
Longevity increase is a very important part of economic growth, broadly defined

- Life expectancy in Mexico:
  - 1960: 57.1 years
  - 2012: 77.1 years
  - Average annual increase: 4.6 months
- Nordhaus (2005) argued that “improvements in health status have been a major contributor to economic welfare over the twentieth century. 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.”
- The United Nations’ Human Development Index (HDI) is a composite statistic of life expectancy, education, and income per capita indicators, which are used to rank countries into four tiers of human development (United Nations (2016)).

Contributions to long-run increase in economic wellbeing



“long-run growth is driven by the discovery of new ideas throughout the world”

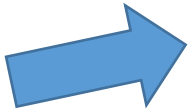
- Prominent macroeconomists such as Chad Jones of Stanford University have argued that “long-run growth is driven by the discovery of new ideas throughout the world.”
- Jones and others postulate an aggregate production function in which total output depends on the total stock of ideas available to this economy as well as on physical and human capital.
- Jones CI (2002). “Sources of U.S. Economic Growth in a World of Ideas,” *American Economic Review* 92 (1): 220-239, March.

Measuring ideas

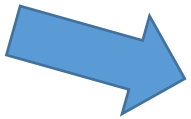
- In general, measuring the number of ideas is challenging—e.g. because most patents never see the light of day—but due to government regulation, measuring pharmaceutical "ideas" is considerably easier than measuring ideas in general.
- **The measure of pharmaceutical ideas I will use is the number of new molecular entities launched.**
- The medical substances and devices sector was the most R&D-intensive major industrial sector: almost twice as R&D-intensive as the next-highest sector (information and electronics), and three times as R&D-intensive as the average for all major sectors.
- Since we have precise information about when those ideas reached the market and the diseases to which they apply, we can assess the impact of those ideas on longevity in a difference-in-differences framework.
- I therefore believe that Nordhaus (2005) may have been unduly skeptical when he wrote that "we cannot at this stage attribute the growth in health income to particular investments or expenditures" and that "apply[ing] the techniques of growth accounting to health improvements…is especially challenging."

- I assess the impact that pharmaceutical innovation had on cancer mortality in Mexico during the period 2004-2014, by investigating whether there were larger declines in mortality for cancer sites (breast, lung, colon, etc.) that were subject to more pharmaceutical innovation, controlling for changes in cancer incidence.
- I also analyze the effect that pharmaceutical innovation had on mean age at death from cancer during the period 1998-2013.

Number of new cancer drugs launched

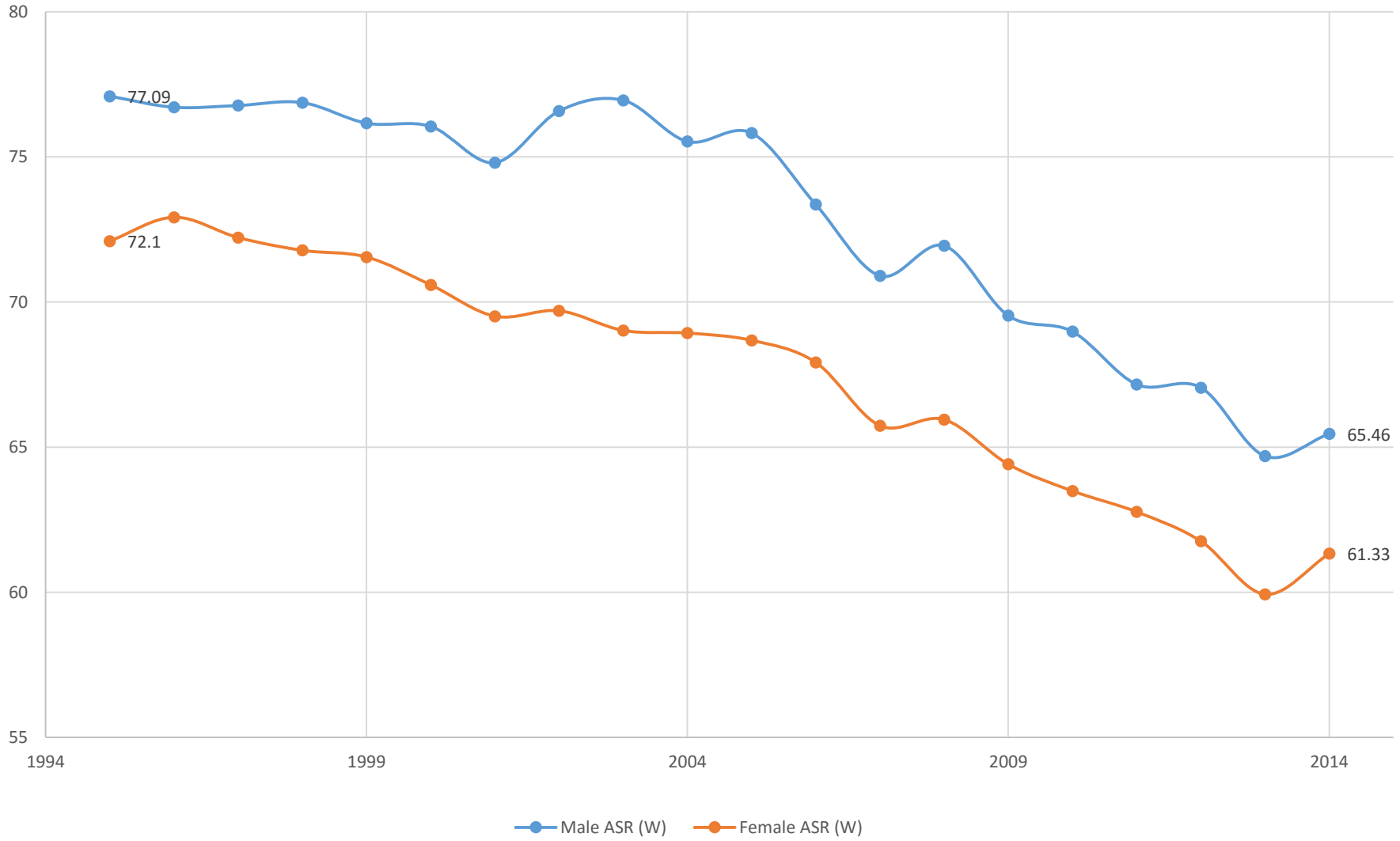


Change in age-standardized mortality rate



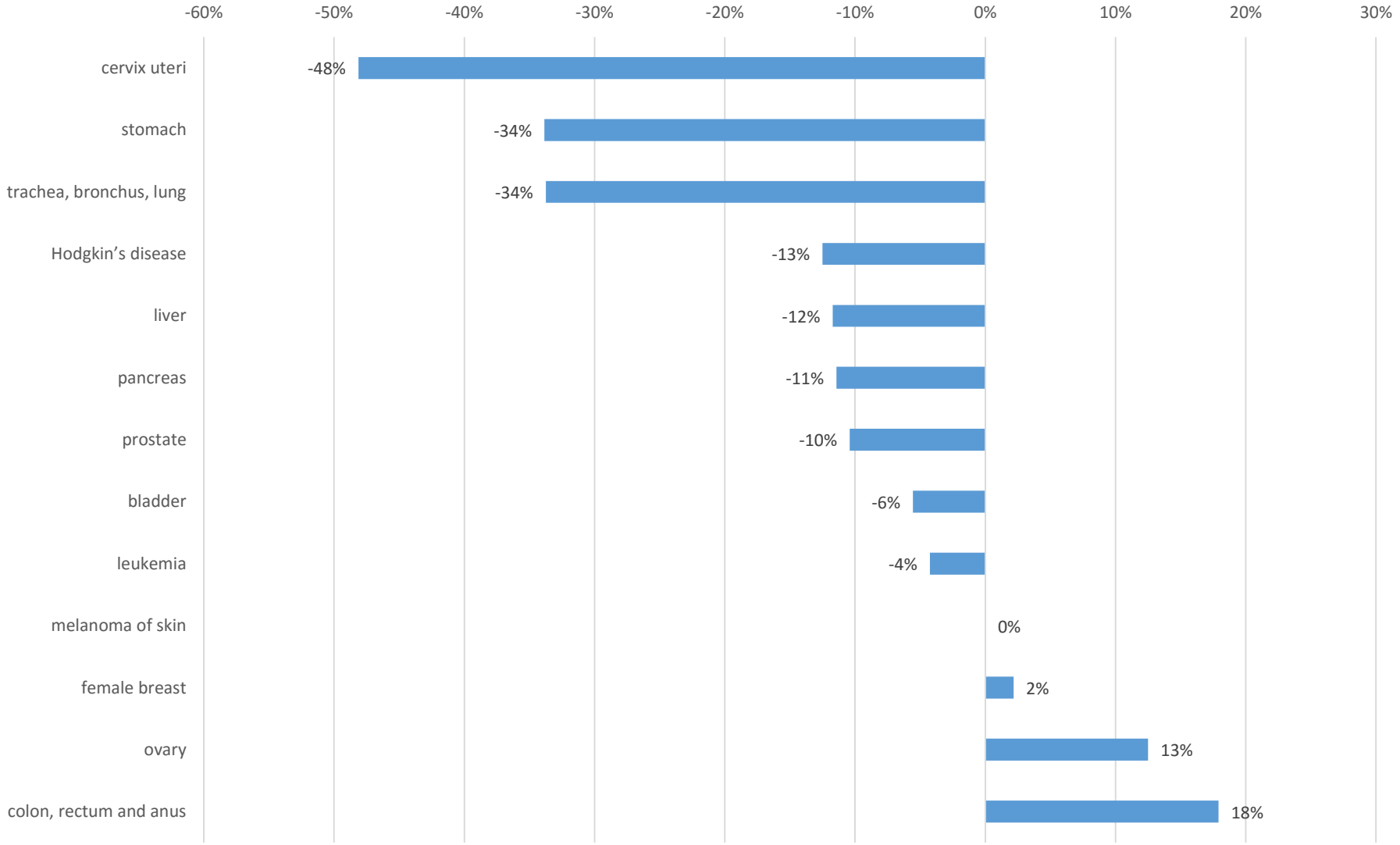
Change in mean age at death

Age-standardized cancer mortality rates, by sex, Mexico, 1995-2014

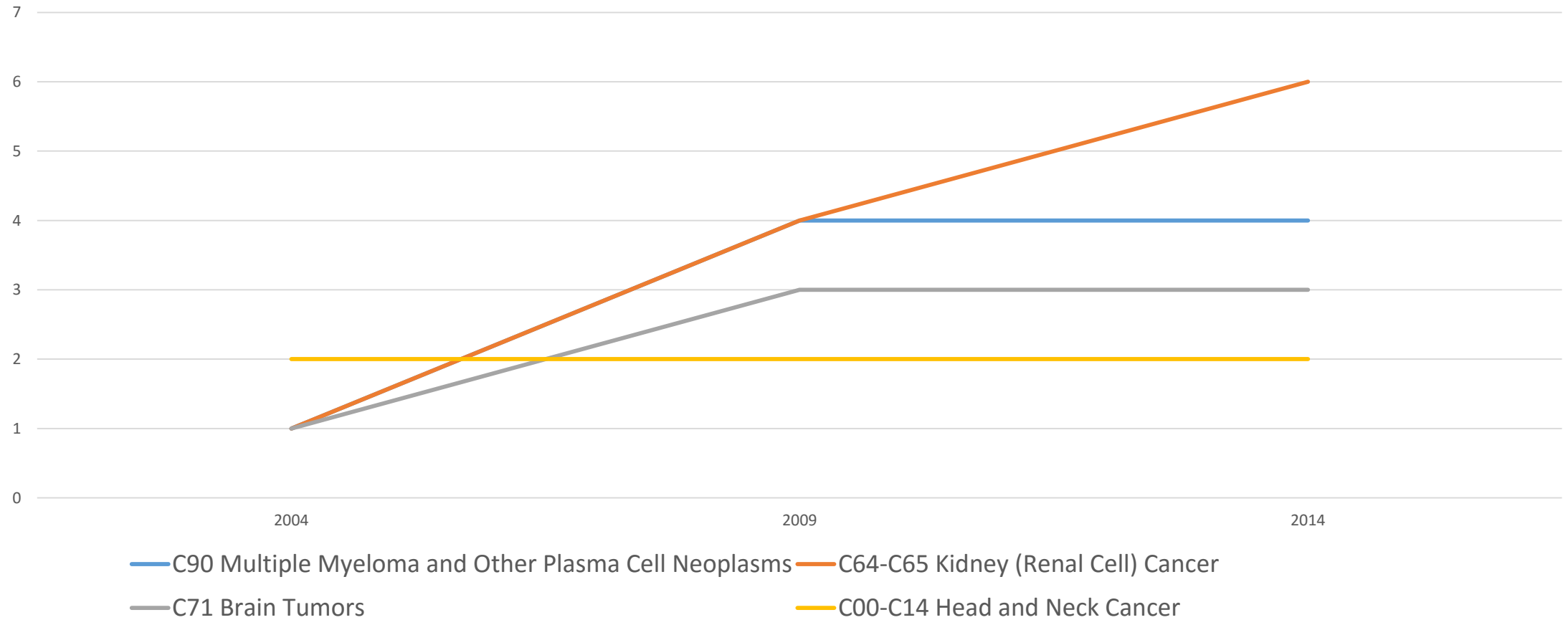


Source: WHO Cancer Mortality database, http://www-dep.iarc.fr/WHOdb/WHOdb.htm.

% change in age-adjusted mortality rate, by cancer site, 2000-2013



Number of drugs launched since 1982 for 4 types of cancer



Data sources

- *Age-standardized cancer mortality rate data* were obtained from the WHO Cancer Mortality Database.
- *Age-standardized cancer incidence rate data* were obtained from GLOBOCAN.
- Data on *mean age at death and number of deaths* were computed from data obtained from the WHO Mortality Database.
- Data on *drugs approved for different types of cancer* were obtained from the U.S. National Cancer Institute.
- Data on *Mexican launch dates of drugs* were obtained from the IMS Health New Product Focus database. This database contains data on drug launches (in Mexico and many other countries) from 1982 to the present.

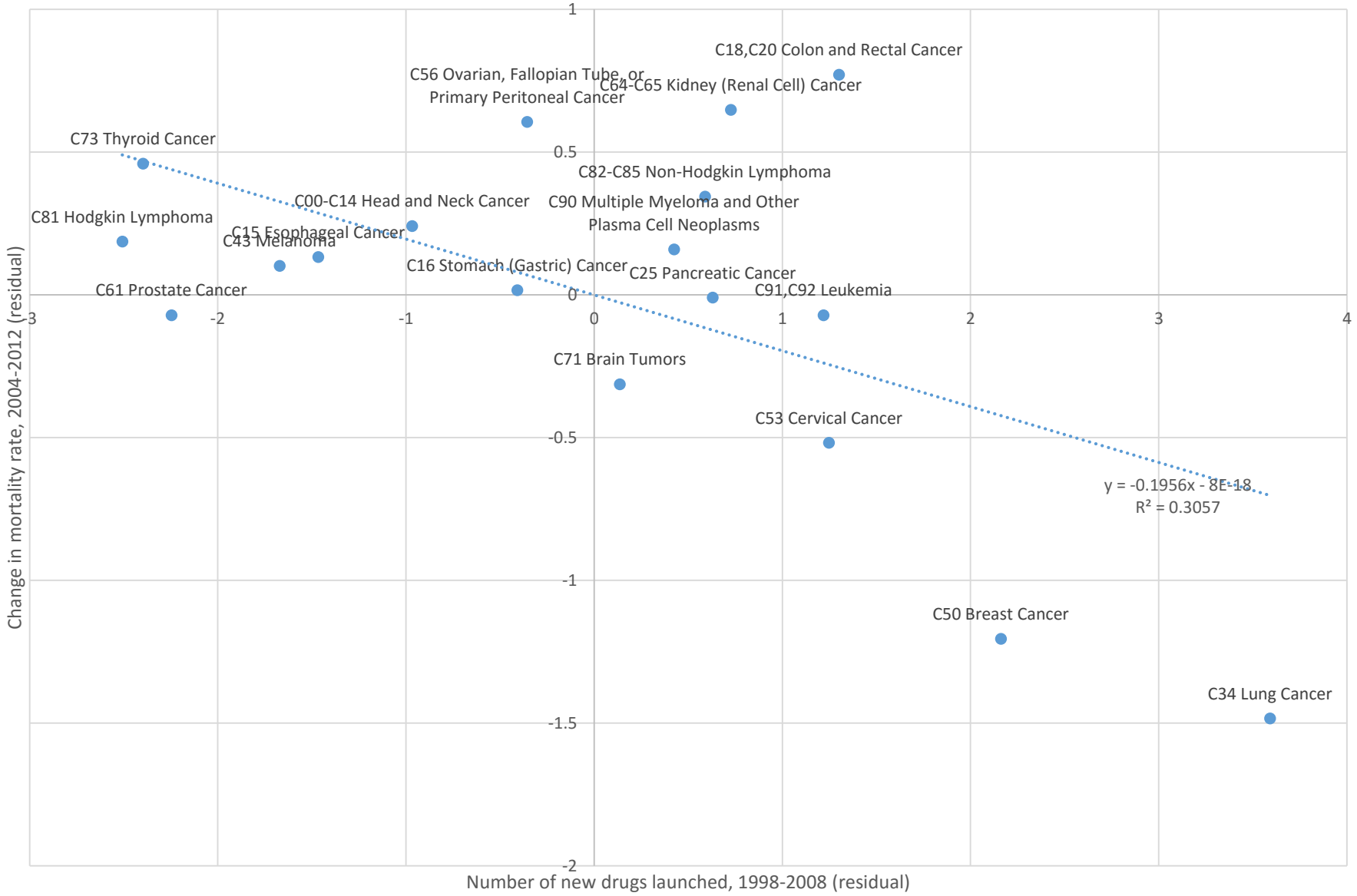
Mexican launch dates of drugs used to treat different types of cancer

Cancer site	Drug	Launch year
C00-C14 Head and Neck Cancer	docetaxel	1995
C00-C14 Head and Neck Cancer	cetuximab	2004
C15 Esophageal Cancer	docetaxel	1995
C15 Esophageal Cancer	trastuzumab	2000
C16 Stomach (Gastric) Cancer	docetaxel	1995
C16 Stomach (Gastric) Cancer	trastuzumab	2000
C18,C20 Colon and Rectal Cancer	irinotecan	1998
C18,C20 Colon and Rectal Cancer	capecitabine	2000
C18,C20 Colon and Rectal Cancer	oxaliplatin	2002
C18,C20 Colon and Rectal Cancer	cetuximab	2004
C18,C20 Colon and Rectal Cancer	bevacizumab	2005
C18,C20 Colon and Rectal Cancer	panitumumab	2011
C18,C20 Colon and Rectal Cancer	aflibercept	2014

Findings

- There were larger 2004-2014 declines in mortality for cancer sites (breast, lung, colon, etc.) that were subject to more pharmaceutical innovation, controlling for changes in cancer incidence.
- There were larger 1998-2013 increases in mean age at death from cancer sites (breast, lung, colon, etc.) that were subject to more pharmaceutical innovation.

Relationship across cancer sites between the number of new drugs launched during 1998-2008 and the 2004-2014 change in the mortality rate, controlling for the 2002-2012 change in the incidence rate



Age-standardized mortality and incidence rates and number of post-1981 NCEs ever launched, by cancer site

	mortality rate		incidence rate		No. of NCEs ever launched					
Cancer site	**2004**	**2014**	**2002**	**2012**	**1989**	**1994**	**1999**	**2004**	**2009**	**2014**
C00-C14 Head and Neck Cancer	3.2	2.6	3.4	1.0	0	0	1	2	2	2
C15 Esophageal Cancer	1.1	0.9	1.5	1.0	0	0	1	2	2	2
C16 Stomach (Gastric) Cancer	6.3	4.8	11.3	6.9	0	0	1	2	2	2
C18,C20 Colon and Rectal Cancer	3.7	4.5	7.5	7.8	0	0	1	4	5	7
C25 Pancreatic Cancer	3.9	3.5	4.7	3.8	0	0	3	3	6	6
C34 Lung Cancer	8.6	5.7	11.9	7.5	0	1	5	6	10	11
C43 Melanoma	0.5	0.5	1.6	1.8	1	1	2	3	3	5
C50 Breast Cancer	4.7	4.8	13.2	17.7	1	2	8	12	16	17
C53 Cervical Cancer	4.8	3.2	14.8	11.7	0	0	0	0	3	3
C56 Ovarian Cancer	1.7	1.9	3.7	2.8	0	1	3	3	5	5
C61 Prostate Cancer	5.8	5.2	15.0	13.7	3	4	6	6	6	8
C64-C65 Kidney (Renal Cell) Cancer	1.9	2.0	4.7	3.5	0	0	1	1	4	6
C71 Brain Tumors	2.1	1.9	3.0	3.9	0	0	1	1	3	3
C73 Thyroid Cancer	0.5	0.6	3.4	2.6	0	0	0	0	0	1
C81 Hodgkin Lymphoma	0.5	0.4	1.7	1.3	0	0	0	0	0	1
C82-C85 Non-Hodgkin Lymphoma	2.2	2.2	4.8	4.1	1	1	2	2	5	6
C90 Multiple Myeloma and Other Plasma Cell Neoplasms	1.0	1.0	1.4	1.3	0	0	0	1	4	4
C91,C92 Leukemia	3.5	3.5	5.0	5.6	2	3	4	5	8	9
Average	3.1	2.7	6.2	5.4	0.4	0.7	2.2	2.9	4.7	5.4

Mean age at death and number of deaths, by cancer site, 1998 and 2013

	mean age at death		number of deaths	
Cancer site	**1998**	**2013**	**1998**	**2013**
C00-C14 Head and Neck Cancer	66.3	66.5	767	1057
C15 Esophageal Cancer	68.9	69.0	704	958
C16 Stomach (Gastric) Cancer	66.6	65.9	4688	5365
C18 Colon Cancer	65.6	65.9	1914	4021
C20 Rectal Cancer	63.7	63.3	372	682
C25 Pancreatic Cancer	67.6	68.3	2545	3726
C34 Lung Cancer	68.0	69.4	6200	6412
C43 Melanoma	63.5	65.7	313	554
C44 Basal Cell Carcinoma	71.5	74.8	661	947
C45 Malignant Mesothelioma	60.9	64.3	108	232
C46 Kaposi Sarcoma	51.3	50.0	12	8
C49 Soft Tissue Sarcoma	50.8	54.3	404	680
C50 Breast Cancer	57.7	59.9	3404	5386
C53 Cervical Cancer	59.1	59.7	4538	3693
C56 Ovarian Cancer	58.5	59.6	1113	2022
C61 Prostate Cancer	76.9	78.0	3535	5768
C64-C65 Kidney (Renal Cell) Cancer	62.0	64.3	1152	1982
C71 Brain Tumors	47.0	51.7	1218	1977
C73 Thyroid Cancer	66.7	67.8	348	646
C81 Hodgkin Lymphoma	48.9	55.0	445	489
C82-C85 Non-Hodgkin Lymphoma	54.7	61.1	1458	2199
C90 Multiple Myeloma and Other Plasma Cell Neoplasms	64.0	64.8	595	1053
C91 ALL, CLL, and Hairy Cell Leukemia	28.9	35.4	1444	2026
C92 AML & CML	43.0	50.1	1053	1344

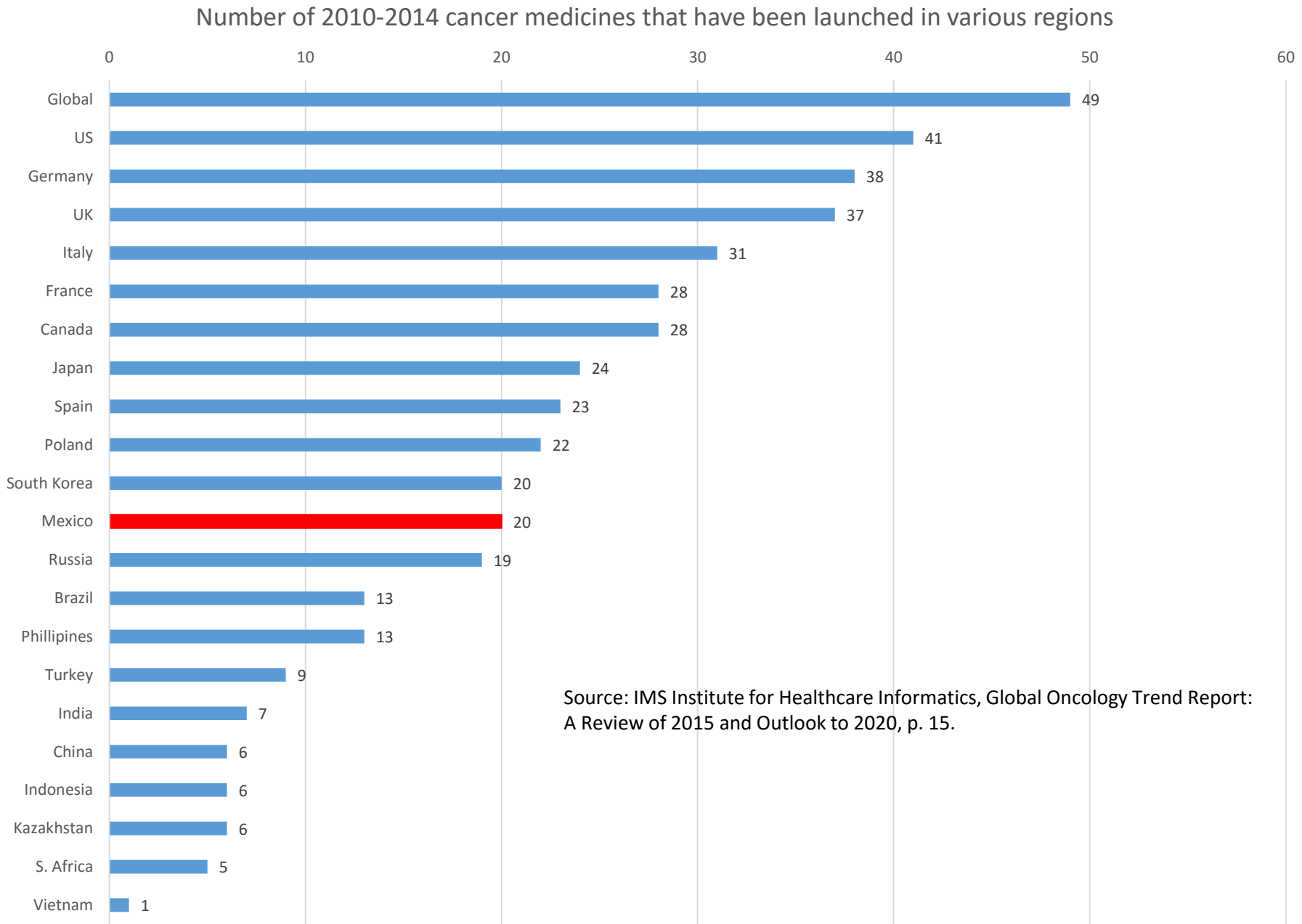
New drug launches reduced cancer mortality

- The estimates indicate that the launch of new drugs reduced cancer mortality in two ways:
  - it reduced the probability that people would die from cancer
  - it increased the mean age at which people died from cancer
- New drugs launched during 1998-2008 are estimated to have reduced the age-standardized cancer mortality rate by 15%, i.e. at an average annual rate of about 1.5%.
- Also, one-third to one-half of the 1.74-year increase in mean age at death from cancer between 1998 and 2013 is estimated to have been due to pharmaceutical innovation.

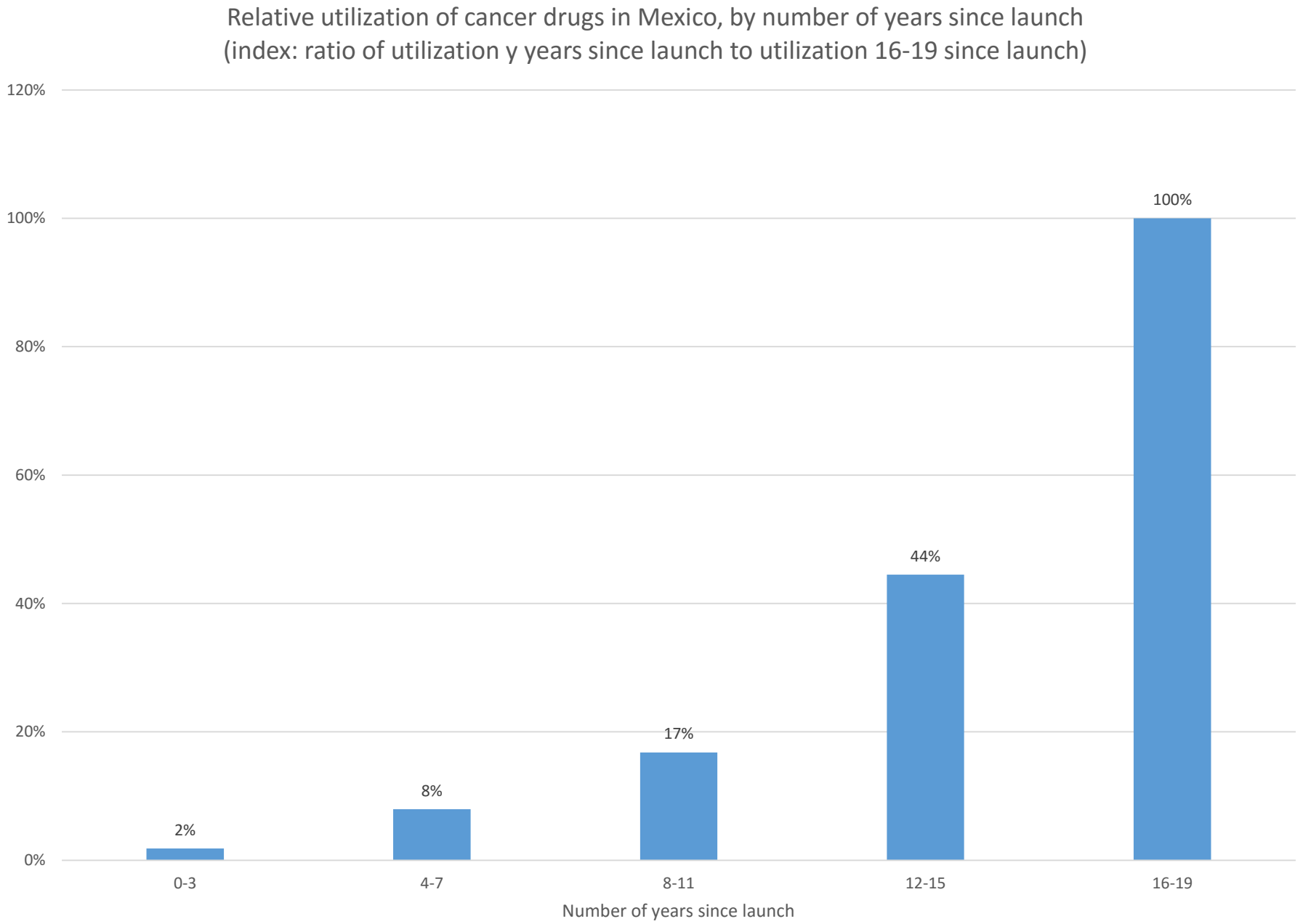
Life-years gained and cost-effectiveness

- I estimate that 105,661 life-years before age 70 were gained in 2013 due to cancer drugs launched during 1997-2007
- The estimated cost per life-year gained was in the neighborhood of $2120.
- By the standards of the World Health Organization, new cancer drugs have been very cost-effective in Mexico.

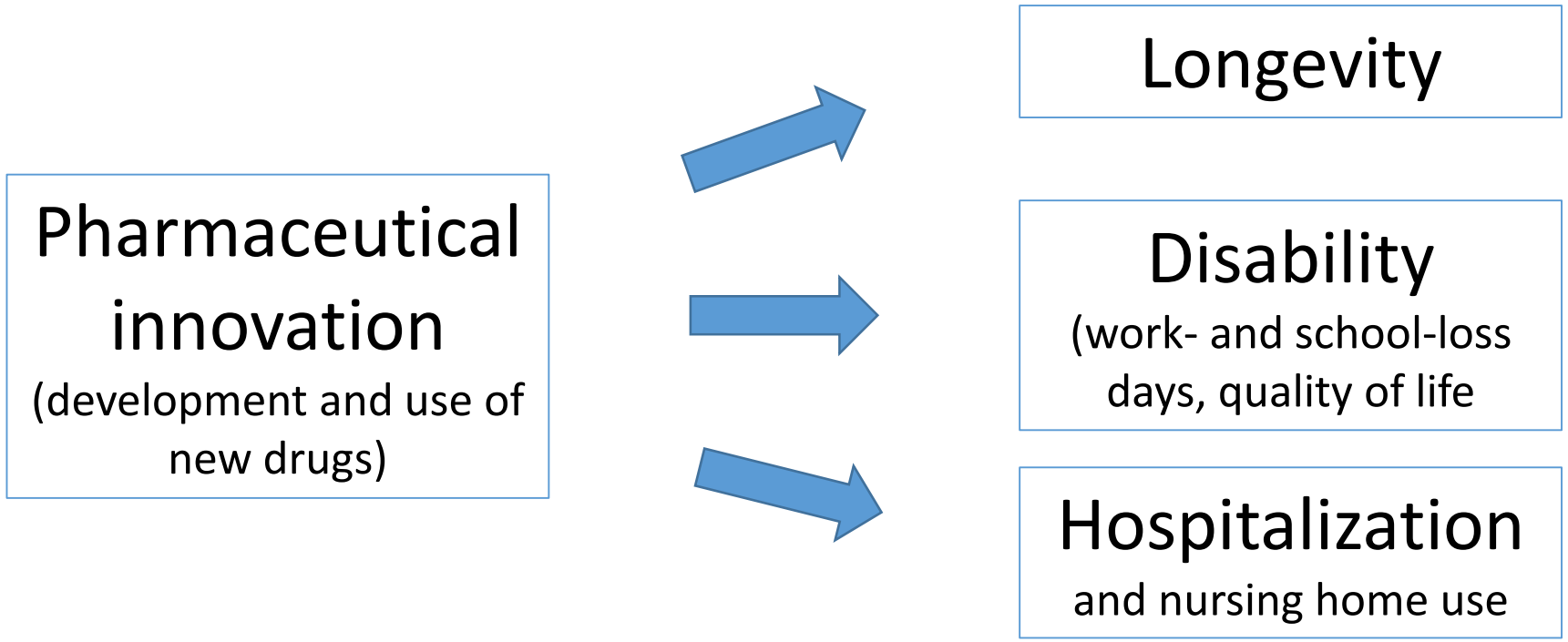
- The contribution of cancer drug innovation to Mexican longevity growth has been valuable, but perhaps it could have been even larger.
- Only half as many new cancer drugs were launched in Mexico during 2010-2014 as were launched in the U.S.
- Also, when new drugs are launched in Mexico, their diffusion tends to be quite slow.



Source: IMS Institute for Healthcare Informatics, Global Oncology Trend Report: A Review of 2015 and Outlook to 2020, p. 15.


Relative utilization of cancer drugs in Mexico, by number of years since launch
(index: ratio of utilization y years since launch to utilization 16-19 since launch)
120%
100%
80%
60%
40%
20%
0%
2%
8%
17%
44%
100%
0-3
4-7
8-11
12-15
16-19
Number of years since launch

Three types of health outcomes

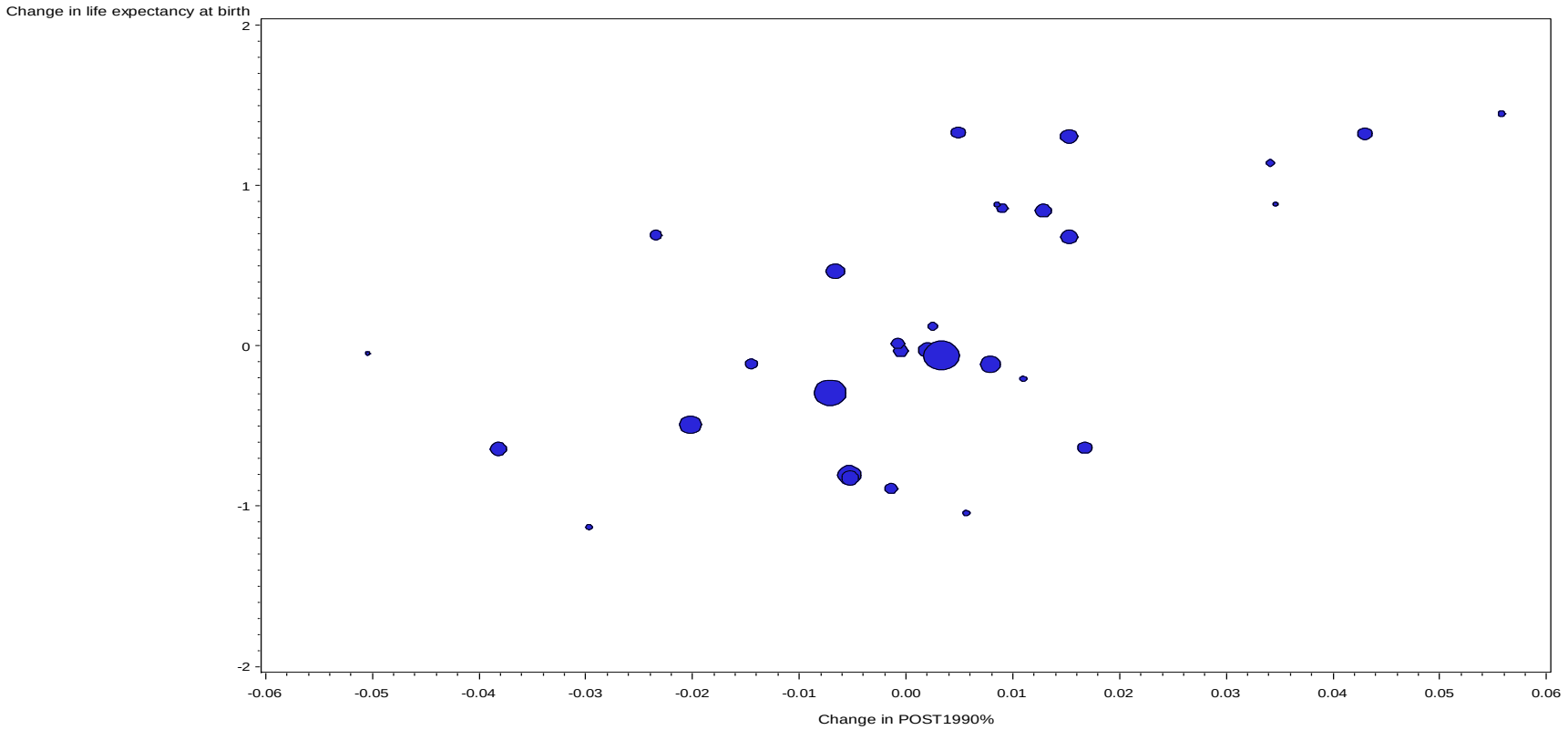


3 alternative research designs

- **Patient-level data**: do patients using new drugs have better health outcomes than patients using older drugs?
- Longitudinal data on different **regions**: has longevity increased more in countries or states that have adopted more pharmaceutical innovations?
- Longitudinal data on different **diseases**: has mortality declined more for diseases that have adopted more pharmaceutical innovations?

Correlation across countries between 2000-2009 change in life expectancy at birth and change in drug vintage (POST1990%),

controlling for changes in income, unemployment rate, education, urbanization, health expenditure, immunization rate, HIV prevalence and tuberculosis incidence



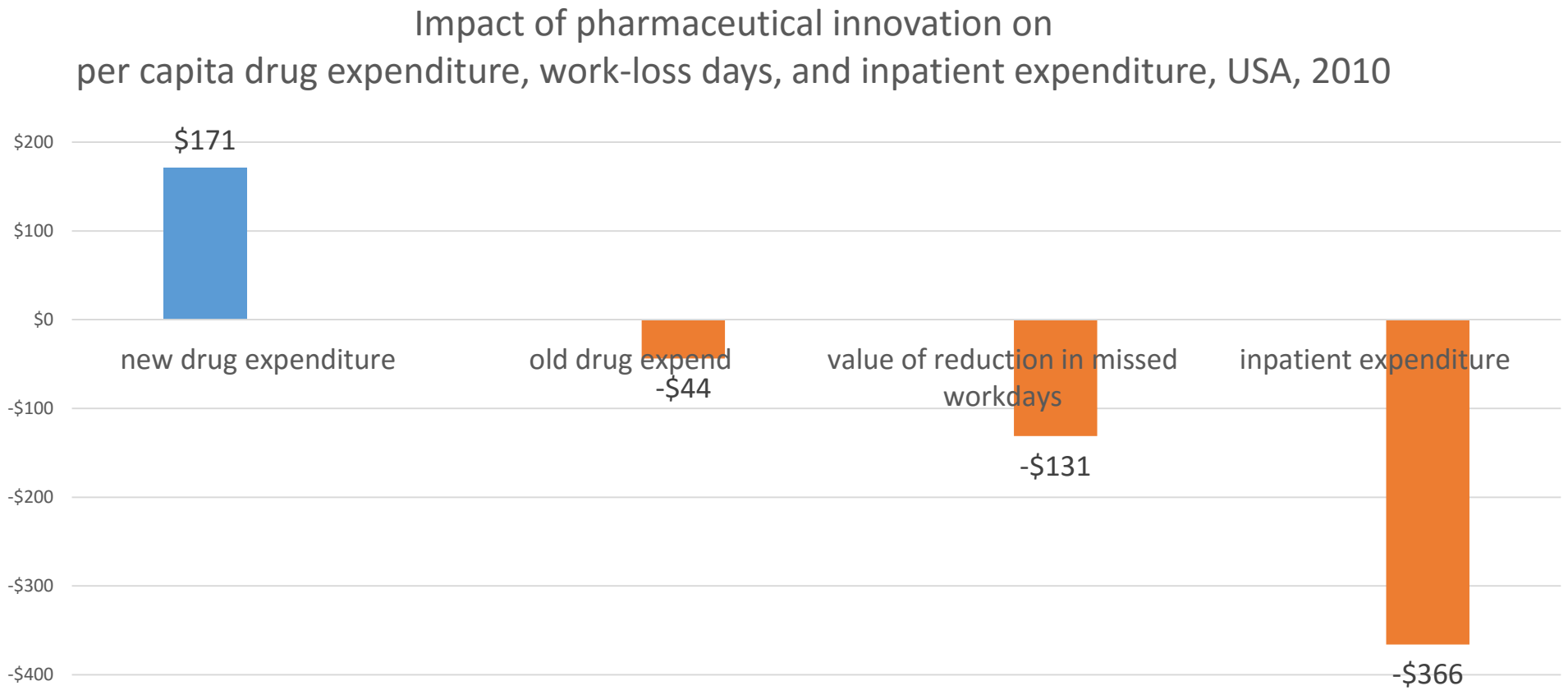
Pharmaceutical innovation accounted for 73% of the 2000-2009 increase in life expectancy at birth in 30 countries (1.27 years of the 1.73 year increase)

Note: size of bubble is proportional to country population.

Lichtenberg FR (2014). Pharmaceutical Innovation and Longevity Growth in 30 Developing and High-income Countries, 2000-2009 *Health Policy and Technology* 3(1): 36-58, March.

Pharmaceutical innovation is often *cost-saving*, not just cost-effective

- In a recent study (Lichtenberg (2014)), I investigated whether diseases subject to more rapid pharmaceutical innovation experienced greater declines in Americans' disability days and use of medical services during the period 1997–2010, controlling for several other factors, using data from a U.S. government household survey.
- The mean number of work loss days, school loss days, and hospital admissions declined more rapidly among medical conditions with larger increases in the mean number of new (post-1990) prescription drugs consumed.
- The value of reductions in work loss days and hospital admissions attributable to pharmaceutical innovation was estimated to be three times as large as the cost of new drugs consumed.
- Lichtenberg FR (2014), "The impact of pharmaceutical innovation on disability days and the use of medical services in the United States, 1997-2010," *Journal of Human Capital* 8(4): 432-480.



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