The Growth of Health Spending in the USA: 1776 to 2026

Thomas E. Getzen
Philadelphia, PA USA
getzen@temple.edu

12 December 2017 {replaces 05 September version)

JEL No. I1, J11, N30, O35, H51, E01

Abstract: This review utilizes a number of historical and contemporary sources to trace the growth of national health expenditures in the United States from 1776 to 2026, supporting four empirical generalizations:

1) Expenditures follow a typical *S-shaped* exponential growth curve; a long slow rise followed by a period of rapid increase that eventually moderates and stabilizes.
2) There are lags between macroeconomic fluctuations and corresponding changes in health expenditure. Examination of annual data can estimate business cycle lags on the order of 3 to 6 years with confidence. There may also be low-frequency lags over multiple decades that cannot yet be clearly delineated with the available data.
3) The health share of GDP remained relative stable from 1930-1955, rising only slightly despite major advances in technology, organization and financing.
4) Peak rates of growth occurred during the decade 1960-1970 as the modern national health system took shape. This surge in spending was fostered by large public investments in workforce training, buildings, equipment and research that began prior to the implementation of Medicare and Medicaid.
5) Growth was significantly more rapid from 1975-1995 than from 1995-2015 for reasons that are not fully clear.

Modern medical care in 2015 is still recognizably close in form to the 1970 version, much more so than medical practice in 1970 was to that in 1925 or even in 1945. Highly organized and regulated, with academic medical centers at the core, there is "almost" universal insurance coverage for more than 80% of the population that subsidizes a safety net for the remainder. This patchwork of public and private insurance has cracked and frayed as the health share of GDP expanded toward 20% of GDP making the current system appear unsustainable and portending major revisions within the next twenty years. Issues regarding measurement of national health expenditures, market definition, demographic effects, temporal dynamics, and spending decomposition are discussed, with appendices providing more detail on methods and data sources.

1. Introduction and Overview: Transformation of medicine and health care financing during the 20th Century.

Health care in the United States underwent revolutionary change during the 20th Century, a fact of major importance that can be confirmed with a short glance at the historical record. Yet a single look is not sufficient to understand the complexity or dynamics of the transformation that led to modern high technology medicine with massive expenditure of funds, or why the 19th Century did not experience such forceful upheavals, nor why the 21st Century seems unlikely to do so. Tracing the pattern of growth across all three centuries builds a picture that is both more complex and yet more coherent than any single set of images obtained from a few years or specific therapeutic developments.

Changes in the economy and conditions of life contributed as much or more to the transformation of health and health care as changes in the organization and financing of medical care (**Table 1**). While attention is here focused on medical expenditures relative to income, it is important to remain aware that multiple developments are occurring in concert rather than separately.

Table 1: 20th Century Medical Transformation

Before <1900	**AFTER 2000 >**
solo doctors	**Health Systems**
personal payments	**Third-Party Financing**
< 3% of GDP	**>15% of GDP**
life expectancy <48	**Life Expectancy >78**
rural/agriculture	**Urban/Services**
< $6,000 income	**> $50,000 income**

The 20th Century transformation was very valuable and very expensive, quadrupling health spending as a share of GDP (Figure 1a).[1] During the 18th and 19th centuries health spending grew at a pace similar to or slightly above other consumption. After 1880 accumulating

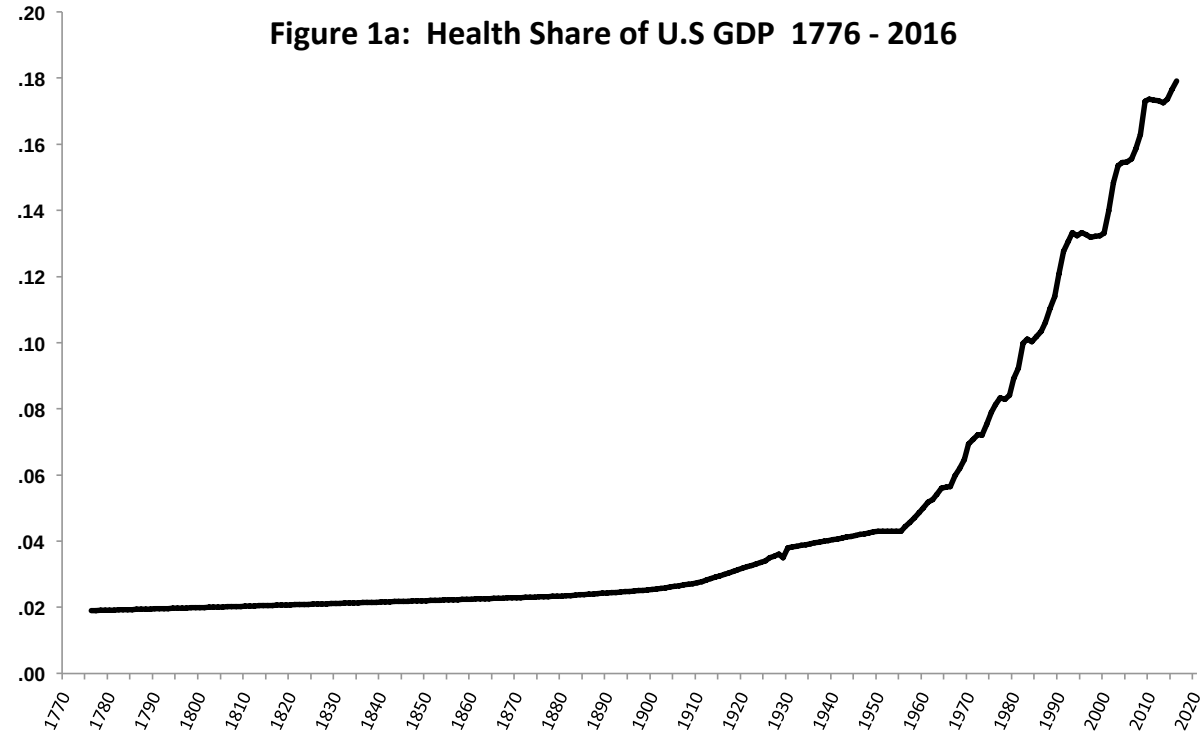


Figure 1a: Health Share of U.S GDP 1776 - 2016
.20
.18
.16
.14
.12
.10
.08
.06
.04
.02
.00
1770
1780
1790
1800
1810
1820
1830
1840
1850
1860
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

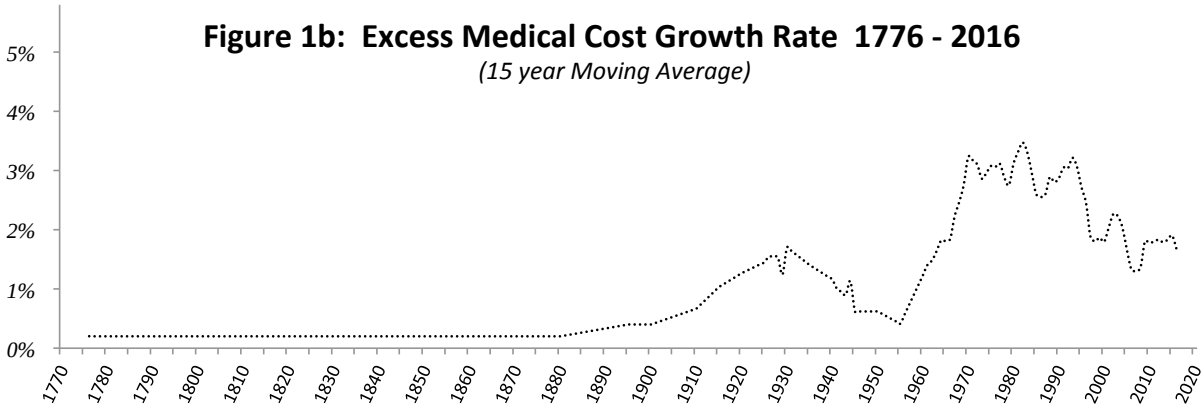


Figure 1b: Excess Medical Cost Growth Rate 1776 - 2016
(15 year Moving Average)
5%
4%
3%
2%
1%
0%
1770
1780
1790
1800
1810
1820
1830
1840
1850
1860
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

advances in medical science and a general increase in living standards pushed the rate of growth higher. By 1930 health spending reached almost 4% of GDP, then stayed at or near that level during the depression, WWII and post-war years. A series of public investments and policies spurred major increases in spending after 1955. Growth peaked around 1970, then moderated over the next 50 years (Figure 1b). The sudden and rapid rise in spending after mid-century was pivotal as the U.S. medical care system took on its modern shape and built the grand academic medical centers that were its defining institutions. This article details that gradual rise, sudden surge, and subsequent slowing in the rate of increase in spending for medical care. It argues that rapid expansion was fostered by major public investments in research, workforce and fixed capital structures, as well as the establishment of an extensive third-party financing mechanism.

Review of the literature identified 14 studies that analyzed changes in national trends for periods of twenty-five years or longer. These are listed in **Section II** along with works on national health accounting that provide context. **Section III** outlines growth of the medical sector from 1776 to 2016, examining turning points and trends for sub-periods where structural shifts may have occurred. **Section IV** delineates major regime changes and secondary trend shifts, with particular attention to the coalescence of a truly national health system during the 1960-1970 decade. **Section V** examines the effect of population aging on national health expenditures. **Section VI** reviews CMS and Congressional Budget Office (CBO) spending projections to 2026 and ranges of uncertainty for longer-run forecasts. Consideration of cost trends in relation to demographic changes supports a projection that the elderly are likely to account for more than half of all personal health expenditures by 2050. **Section VII** discusses the 20th century medical transformation in a developmental setting, with regime change from scientific advances dependent on prior economic gains due to the industrial revolution and demographic transition. The role of technology and the breakdown of voluntary norms for pricing and financial management are then examined. **Section VIII** concludes by briefly reviewing the main empirical generalizations that are supported by the historical data and records. It then lists several issues requiring further investigation. **Appendix A** details data sources and extrapolation methods used and **Appendix B** examines measurement issues regarding the boundaries of budgetary allocation, units of observation and temporal dynamics.

As a review essay rather than a presentation of new data or theoretical results, the order and style of exposition used here differs from the usual research report format. Contributions of this paper lie in assembling historical data to place the 20th century transformation of medical care and health expenditures in context, combining employment and expenditure data from

multiple sources, and the analysis of temporal dynamics. Filtering out transitory fluctuations due to business cycles, unsynchronized seasonal adjustments and other noise more clearly reveals the excess growth in health spending that has raised the medical share of GDP six-fold, from less than three percent to more than seventeen percent. Tracking the expenditure record over more than a century is necessary to assess regime changes, ranges of uncertainty, and projections of health spending over the long run.

2. Prior Research and Sources

The earliest fragmentary data are derived from "city directories" listing occupational categories for residents of Boston, Baltimore, Charlestown, New York, Philadelphia, and elsewhere starting in 1772 (Lindert & Williamson, 2016; GPIH, 2017). The decennial U.S. Census began collecting data on personal occupations of respondents beginning in 1850 and continuing through 1990, providing a long series that can be used as a proxy for expenditures. Surveys of family spending were carried out toward the end of the 19th Century by the U.S. Bureau of Labor Statistics (BLS). A set of 15 representative consumer budgets was compiled and a more representative and inclusive Consumer Expenditure Survey (CEX) was used to determine budget item weights for the 1918 consumer price index (BLS 1920, 1924). The first comprehensive assessment of national health spending appears to have been made by Louis I. Dublin (1927), past-president of the American Statistical Association and a VP at Metropolitan Life Insurance Company who wrote *"the best estimate of the aggregate cost of sickness in the United States is over two billion dollars a year…three and a half percent of the country's income…approximately 150,000 physicians, whose average net income is a little more than $3,000 a year."*[2] Dublin became a member of the Committee on the Cost of Medical Care (CCMC) that estimated total U.S. national health expenditures at $3,656 million dollars, approximately $30 dollars per person or 4% of national income in 1929, given a number of caveats and qualifications (CCMC, 1932, page 14).

U.S. national health accounting originated in the extensive 28-volume report of the CCMC published in 1932 (Perkins (1998); Fetter (2006)). For the next three decades researchers at the Federal Security Agency and its successor, the Department of Health, Education and Welfare, constructed estimates of public and private expenditures, many of which were published in the *Social Security Bulletin* and eventually compiled by Barbara Cooper, Nancy Worthington and Mary McGee in a *Compendium of National Health Expenditures Data* (1973). They relied heavily on the evolving national income and product accounts (NIPA), which included medical care as

one component of personal consumption expenditures after 1929, albeit using somewhat different definitions and methods. The expansion of health insurance, fiscal transfers, differences in budget categories and fiscal years, all rendered this ad hoc process increasingly less satisfactory over time. In 1964 Louis Reed and Dorothy Rice constructed a new set of accounts with the aim of being comprehensive, integrated and comparable to the 1932 CCMC report by incorporating data from the Internal Revenue Service, American Hospital Association, American Medical Association, Veterans Administration, Department of Defense, National Institutes of Health, Public Health Service and other sources (Reed & Rice, 1964). Subsequently, Reed and Ruth Hanft (1966) extended these estimates by providing comparable figures for 1950, 1955, and each year from 1960 to 1965, creating a foundation for the current NHE series. Responsibility was assigned to the Office of the Actuary (OACT) after establishment of the Health Care Financing Administration in 1977 (subsequently renamed the Centers for Medicare and Medicaid (CMS) in 2001) with official estimates published each year in *Health Care Financing Review* along with occasional analyses and projections of future expenditures. The journal also contains a historical review of national health accounts development compiled by Bruce Fetter (2006). After the quarterly *Review* ceased publication in 2009 NHE estimates and projections have been published regularly in *Health Affairs* and in the annual *Medicare Trustees Report.* Documentation of definitions, sources and methods is accessible from the CMS website, along with the most recent set of estimates (CMS, 2015). Major revisions are undertaken about every five years, with the most recent being in 2010 (Haber & Newhouse 1991, Donahoe 2000, CMS 2009, 2010). There have also been a number of studies comparing the NHEA with similar estimates from BEA NIPA accounts, BLS Consumer Expenditure Surveys (CEX) and the Medical Expenditure Panel Survey (MEPS), some showing substantial differences of 10% or more.[3] With extensive data tables now available for each year from 1960 to 2015, the NHEA series is widely used and well documented. Yet the details and complexity of the process and the availability of multiple valid alternative measures are not always fully appreciated. The various series used to trace the long-run growth of national health spending and the process of reconciling them are described in greater detail in Appendices A and B.

While no prior study has quantitatively evaluated expenditure growth over a century or more, there are at least fourteen that have examined spans of twenty to fifty years (see **Table 2)**.[4] For measuring long run trends, neither nominal increases nor deflated per capita spending are as useful as the share of the health sector as a percentage of GDP (see Appendix B). Expansion of the health sector is most readily measured by the increase in share expressed as

GDP+X, the "excess growth rate" of health expenditures relative to income. Frank Dickinson (1947, 1948, 1951, 1955) and J.R. Seale (1959) cover most of the same years from 1929 to 1956 and reach similar conclusions: an era of relatively steady growth matching the expansion of the economy, with increasing levels of government spending over time. This impression of stability is consistent with the judgments expressed in articles written in the late 1950s by George Stigler (1956), Elizabeth Langford (1957) and Joseph Garbarino (1959) regarding employment and prices. Rice and Cooper (1970) present the official national health expenditure data for 1968, along with a brief review of trends by five-year periods going back to 1929. Reporting that health had risen from 3.5% to 6.6% of GNP over 40 years they attribute most of the growth to "population, prices, utilization and other factors" (including technology), observe that recent growth is more rapid than the long-run average, that hospitals had replaced physicians as the dominant category of spending, and that public financing had increased substantially. Herbert Klarman (1977) incorporates additional years up to 1975 using various definitions of what constitutes an "era" with a focus on questions of policy, insurance and value for money. His skeptical evaluation of prevalent causal explanations leads Klarman to assert that spending growth is likely due to multiple and changing factors over time rather than any single explanation. After using an arbitrary definition of five-year periods and presenting growth in nominal rates he turns to examine health as a share of GDP toward the end of the essay, concluding that "expenditures in this country have moved steadily and markedly upward. Over the past decade, the rate of increase has accelerated. In relation to the GNP, the trend in the United States is similar to that in most developed countries [p232]."

Burton Weisbrod's (1991) influential *Journal of Economic Literature* essay used anecdotes and qualitative analysis rather than econometrics to explore how interactive feedback between insurance financing, R&D and technological advances changed the structure of medicine and fostered cost increases during the preceding decades. His statement "…the operational definition of health care—that is, on the boundaries of the insurance contract" makes it evident that he assumes a different economic regime from that of the 1930s characterized by personal medical fees.[5] Joseph Newhouse's (1992) *Journal of Economic Perspectives* article the following year was more focused on cost measurement and labels each ten-year period as an era. Newhouse argues that too much importance has been assigned to population aging, personal income, physician supply, utilization and insurance, and is quite reserved in delineating phases of growth or rates of technological change, noting on page 11 "Trying to attribute a residual to a specific factor is an inherently frustrating exercise, and the best I can do to support my argument that much of the

residual is attributable to the new capabilities of medicine (i.e., "technology)---is to buttress it with data I believe are consistent with it." Like Klarman, Newhouse asserts "the real rate of increase in costs is similar across countries."

Table 2. Trends in U.S. NHE Growth: Studies of 20+ year spans

Dickinson (1948, 1951, 1955)	*1929-1953*
Seale (1959)	*1929-1956*
Rice & Cooper (1970)	*1929-1968*
Klarman (1977)	*1929-1975*
Weisbrod (1991)	*1940-1990*
Newhouse (1992)	*1950-1990*
Cutler, Rosen, Vijan (2006)	*1960-2000*
Murphy & Topel (2006)	*1950-2000*
Hall and Jones (2007)	*1950-2002*
Chernew & Newhouse (2012)	*1960-2009*
Chandra, Holmes, Skinner (2013)	*1970-2012*
Catlin & Cowan (2015)	*1960-2013*
Horenstein & Santos (2016)	*1970-2007*
Chen & Goldman (2016)	*1960-2013*

David Cutler, Allison Rosen and Sandeep Vijan's "The Value of Medical Spending in the United States, 1960-2000" in the *New England Journal of Medicine* examines spending and mortality across four age groups and five decades, providing evidence that marginal productivity has fallen over time and was lower for older age groups. A more elaborate and formalized model of changes in life-expectancy from 1950 to 2000 by Murphy & Topel (2006) appeared in the *Journal of Political Economy* in the same year. Hall & Jones (2007) use similar data from 1950 to 2000 to analyze welfare effects in a general equilibrium macro model. Concerned primarily with the fitting and calibration of a utility function rather than the empirical variations in temporal dynamics, they state simply that "we assume a period in the model is five years [page 53]." A review article by Michael Chernew and Newhouse (2012) observes that the cumulative average annual excess growth of 2.2% is unequally divided across seven decades, noting a reduction in

the mid-1990s but concluding on page 37 "historical data do not indicate any persistent slowing in healthcare spending growth." Amitabh Chandra and Jonathan Skinner in their *Journal of Economic Literature* review article make a conceptual and theoretical distinction between three types of medical technology; cost-saving, sometimes effective, and expensively uncertain. In a subsequent paper, Chandra, Jonathan Holmes and Skinner (2013) take significant moderation in cost growth since 2000 as a starting point for their empirical time-series study and, while remaining skeptical about continued slow growth in the future, predict excess cost growth of GDP+1.2% for the next two decades, less than half as much as during the prior fifty years.

Several recent studies attempt to make meaningful historical distinctions in NHE trends by dividing the last half-century into 3, 4, 5, or 8 eras of varying length with differing starting and ending points. OACT researchers Aaron Catlin and Cathy Cowan (2015) divide the 1960-2013 span into eight parts at 1965, 1973*a*, 1982*b*, 1992, 1999*a*, 2002*b*, and 2007*a* (using *a* and *b* to designate sub-eras).[6] Alice Chen and Dana Goldman (2016) divide the same span into four eras at 1973, 1995, and 2002. Both studies link period markers to public policies and nominal growth rates, but do not refer to quantified dimensions of organization or insurance, or provide analysis of temporal dynamics and lags in macroeconomic adjustment. Alex Horenstein and Manuel Santos (2016) split the 1970-2007 span into three eras with divisions at 1977 and 1990, using comparative data on ten OECD countries to make a case that most of the divergence in costs between the USA and other developed nations occurred during the 1978-1990 period. Chandra, Holmes and Skinner (2013) divide the 1990-2012 span into four periods with divisions at 2001, 2007, and 2009. Differences in classification for the same years across studies may indicate that time series dynamics and noise make it hard define meaningful eras with lengths of less than fifteen years.

3. Historical Trends over the last 200+ Years

1776–1880: Pre-Clinical Science and Medical Nihilism. George Washington, first president of the United States, began to feel ill on Thursday December 12 1799. He had been quite healthy, riding for miles and chopping wood the previous day, but came down with a sore throat after riding in the cold rain. On Friday, he asked an overseer at Mt. Vernon, George Rawlins, to bleed him for relief, and also sent for a doctor. Dr. James Craik arrived late that evening and bleed Washington again. Repeated bleedings, hot compresses and other efforts were of no avail. Washington's breathing became labored and on Saturday night he died (Wallenborn

1997; Mount Vernon 2017). The best medical practices of the time did not help, and may actually have hastened his death.

Benjamin Rush was surgeon-general of the Continental army and signed the Declaration of Independence in 1776. After becoming professor of chemistry at what is now the University of Pennsylvania Medical School, Rush published numerous medical papers and books (Rush 1815, Osler 1922, King 1991). He rose to fame during the yellow fever epidemic of 1793, bravely staying in Philadelphia to treat hundreds of gravely ill patients when most business leaders and physicians fled the city to escape infection. Among the most celebrated of 19th Century physicians, his students founded Rush Medical College of Chicago in his honor in 1837. That said, the medical practices of Dr. Rush were of questionable benefit. He championed "heroic medicine" writing a lengthy treatise defending frequent blood-letting and using a proprietary purgative named "Dr. Rush's Thunderbolts" compounded of calomel, jalap and mercury whose major effect was to cause explosive effusions from mouth and anus. Even some of Rush's contemporaries claimed that he killed more patients than he cured. Still, he was one of the outstanding physicians of the era. In addition to his chemical and surgical interventions, Rush did path-breaking work on treatments for mental illness and addictions. He was good for his time; no physician could realistically offer more.

James Garfield, twentieth president of the United States, was shot in the back on July 2, 1881. A changing group of physicians scrambled for control over treatment of the severely injured president. At least eight physicians used their hands, usually unwashed, to probe inside the wound in an attempt to remove the bullet (Millard (2011); Paulson (2006), Rosenberg (1968), Rutkow (2006)). The inventor Alexander Graham Bell brought a metal detector to the bedside in hopes of locating the deep-seated object. After several unsuccessful probes and surgeries, Garfield was moved by train to a seaside cottage for rest. On September 19 he died. Medical experts are divided on Garfield's prospects of survival, with some arguing that doctors probing with dirty fingers caused the infection that brought about his demise, while others suggest that the traumatic injury alone would have inevitably caused death. Given that he survived more than two months, it is likely that modern medical treatment could have provided partial or full recovery within a few weeks or months.

These examples fit within the general assessment of 18th and 19th Century medicine in America as doctors caring for patients and struggling to display therapeutic effectiveness while being of little economic significance.[7] Population and per capita income grew rapidly during the early years of the republic, not health expenditures. The number of people in the USA rose from 3

million to 50 million and their average income tripled (Table 3).[8] At founding, the United States was a rural nation with most households engaged in agriculture. By 1880 more than a 20% lived in cities and over half depended on wages or business income. Medical care, however, was little changed and mostly provided at home by family members rather than purchased in the market.

Table 3: Health Expenditures, GDP, Population and Employment 1776 - 1990

	NHE % GDP	GDP per capita ($1996)	U.S. Pop (millions)	% Urban	Physicians/ 1,000 Pop	Staff per Physician	Health % Employment
1776	1.9	$1,048	2.6	< 5%	-	-	-
1850	2.2	$1,796	23	15%	1.86	0.2	1.0
1880	2.3	$2,177	50	20%	1.77	0.7	0.9
1900	2.5	$4,204	76	40%	1.73	2.0	1.4
1910	2.7	$4,879	92	46%	1.67	2.3	1.4
1920	3.2	$5,401	106	51%	1.31	3.3	1.5
1930	3.8	$6,106	123	56%	1.34	4.4	2.0
1940	4.0	$7,396	133	57%	1.35	4.8	2.2
1950	4.3	$11,076	152	64%	1.34	5.9	2.5
1960	5.0	$13,155	181	70%	1.27	7.6	3.1
1970	6.9	$17,449	205	74%	1.36	10.0	4.3
1980	8.9	$21,568	227	74%	1.89	11.3	5.8
1990	12.1	$26,872	250	75%	2.30	12.6	7.1
2000	13.3	$32,579	282	79%	2.58	12.9	7.7

{Sources: see note[8] and Appendix A}

The number of physicians per 1,000 population declined slightly from 1850 to 1880 (from 1.86 to 1.77), as did the share of the workforce in health occupations, still less than 1% of total employment. Medical costs were relatively minor. Skimping on purchased medical care was a secondary concern, less important than obtaining adequate food, heat and clothing. Despite the lack of perceived therapeutic value, amounts spent on medicines and doctors rose because

incomes rose, and because the increasingly urbanized workers could seek professional care at doctors' offices or clinics rather than at home. There is no definitive evidence that health spending was rising significantly faster than incomes, but it is likely that the national average was rising modestly, with the share increasing less than a quarter percent per year over the hundred-year span.

1880–1910: Therapeutic Influx. Major medical discoveries were made during the nineteenth century (Lister (1867), Osler (1892, Hertzler (1938), Shyrock (1960), Starr (1984), Duffy (1993), Porter (1998), Worboys (2011)). Laennec published his article on the use of the stethoscope for auscultation in 1819. Anesthesia with ether and chloroform was described in multiple publications around 1850. Pasteur put forth his germ theory of disease in 1858, vaccination for anthrax using oxidized bacteria in the 1870s, and rabies treatment in 1886. Lister's 1867 *Lancet* article relied on Pasteur's research to support using carbolic acid to achieve antiseptic surgery. Koch demonstrated his techniques of bacterial culture and isolated the bacillus tuberculosis in 1882. These new developments mostly came from European centers of learning. In the still largely rural USA day-to-day medical practice was little changed and not highly respected. Blood-letting was the most common medical procedure throughout the 18th and 19th Centuries and President Washington did not deem it worthwhile to wait for a doctor to begin lancing his veins. Physicians attending President Garfield neglected to sterilize the wound or even wash their hands as they probed for a bullet.

In 1892 Sir William Osler published his seven-volume textbook *The Principles and Practice of Medicine.* By then the purchase of medical care had already become a consumer staple in the cities and towns, and would reach into rural areas over the coming decades. There is no clear before/after dividing line, but evidence and experience had accumulated sufficiently to drive demand for medical care upward by the turn of the century. The Eleventh Census of the United States in 1900 recorded a rise of health occupations to more than 1% of total employment. The director of that Census Carroll D. Wright, who also served as Commissioner of Labor for Massachusetts (1873-1878) and subsequently for the United States (1885-1905), carried out large-scale surveys reporting expenditures on "sickness" as 2% - 4% of total consumption of industrial workers (Wright 1894, Stigler 1954. Williamson 1967). It should be noted that funeral expenses and coverage for lost wages were often included among sickness expenditures (Rubinow 1913; Murray 2007). These census occupational statistics, considered alongside the various consumer surveys and narrative records the history of medicine, strongly suggest that

the rate of growth in medical spending began to accelerate by 1900, although they are not sufficient to reliably establish the precise level or rate of annual increase.

1910–1930: Formative Years of Medical Organizations. Four related organizational components shaped medicine during the early 19th Century: *education, regulation, specialization, and hospitalization*. Traditional training for doctors included apprenticeship and perhaps some classical Greek and Latin. The 1910 Flexner Report called for medical students to be educated in chemistry, anatomy and physiology, have a college degree, get hospital experience, and conduct laboratory tests (Flexner (1910), Perkins (1998), Beck (2004)). The report suggested emulating the Johns Hopkins University following the German academic program as a model and recommended closing sub-par "diploma mill" schools. A restrictive movement to raise the quality of practice was applied to the workforce through licensure (Shyrock (1967), Starr (1984), Kleiner (2016)). 19th century practice had legally been open to anyone who chose to designate themselves a doctors. By 1930 state laws and medical boards effectively limited the number of physicians in practice by imposing licensure. Relative to population, the availability of physicians fell by a third even as therapeutic effectiveness, and therefore demand, was growing. Constricting physician supply shifted the workload to ancillary staff. Previously limited to apprentices and a few nurses, the number of assistants per doctor tripled (see Table 3 above).

Advanced scientific training and the devolution of routine tasks to assistants led more and more physicians to specialize (Rosen, 1944; Stevens, 1971). To be an expert in the eye, the ear, the hand, or the stomach, a doctor could no longer learn all there was to know about the full range of diseases, nor spend time wrapping bandages, travelling to make visits out in the country, compounding basic drugs, or carrying out multiple batches of routine chemical tests. Advanced training in medical specialties was overseen by a growing number of physician organizations or specialty boards, with the American College of Surgery founded in 1913, Ophthalmology in 1916, Radiology in 1923, and Internal Medicine in 1936. Concurrent with the development of graduate medical education, licensure, and specialization, hospitals began to change from institutions for the poor and disabled to being centers of advanced practice with concentrations of equipment and trained ancillary staff (Thompson & Goldin 1975; Vogel 1980; Rosenberg 1987; Stevens 1998; see also discussion of hospitals below). By 1930 there were 6,613 hospitals with 974,115 beds. Some were large and formally to linked to medical schools for training and research.

Table 4 Consumer Expenditure Surveys 1909 – 1931

	Share	Medical	Total
1909	2.7	$780	$29,143
1914	2.6	869	33,619
1919	2.9	1,943	65,890
1921	3.1	1,849	59,031
1923	3.1	2,198	70,158
1925	3.0	2,396	79,303
1927	3.1	2,614	83,347
1929	3.2	2,904	89,370
1931	3.7	2,344	63,644

Source: W.H. Lough (1935) *High Level Consumption;* also in HSUS (1976) Tables G470, G486.

William H. Lough (1935) carried out an extensive study of consumption in the U.S. economy with estimates for selected years from 1909 to 1931, indicating that medical care rose from 2.7% to 3.7% of the aggregate total, implying an excess growth rate of +1.5% annually over the twenty-two year span [**Table 4**, Lough, 1935; HSUS, 1976).[9] Over the same period, health employment grew 1.8% per year faster than total employment, although the number of physicians per 1,000 population fell -1.1% per year.[10] Given the ambiguities and measurement difficulties, a reasonable estimate of the average excess growth rate from 1910 to 1930 would be above +1.2% but below +1.8% per year, a substantial acceleration relative to the prior century.[11]

The 1932 CCMC reports constituted a major advance in measurement methodology. Rather than extrapolating totals from a sample of individual consumer spending records or corporate receipts, analysts combined and reconciled multiple sources. Instead of occasional patient bills, many of which were only partially paid, the aggregate revenues of hospitals could be used. Similarly, the income and business records of physicians provided a useful aggregate estimate to compare with the myriad of individual payments. The CCMC categorized spending by type (hospital care, physician services, pharmaceuticals, etc.) and source of funds (personal, government, employer, philanthropy) as well as sub-categorizations by age, income and concentration, establishing a framework utilized and extended in later years. These line item estimates show how different medicine was in 1929, often in ways that make comparisons with the medical spending of today a stretch **[Table 5]**.

Table 5: CCMC Estimates of Total Expenditures for Medical Care, 1929

	TOTAL	Patients	Government	Philanthropy	Industry
	(Thousands)				
Physicians - (private practice)	$1,090,000	1,040,000	- - -	- - -	50,000
Dentists - (private practice)	$445,000	445,000	- - -	- - -	- - -
Sectarian Practice	$193,000	193,000	- - -	- - -	- - -
Graduate Nurses - (private duty)	$142,000	142,000	- - -	- - -	- - -
Practical Nurses - (private duty)	$60,000	60,000	- - -	- - -	- - -
Hospitals - (operating expenses)	$656,000	278,000	300,000	54,000	24,000
Hospitals - (new construction)	$200,000	- - -	100,000	100,000	- - -
Public Health	$121,000	- - -	93,500	27,500	- - -
Private Laboratories	$3,000	3,000	- - -	- - -	- - -
Orthopedic Supplies	$2,000	2,000	- - -	- - -	- - -
Glasses	$50,000	50,000	- - -	- - -	- - -
Drugs	$665,000	665,000	- - -	- - -	- - -
Organized Clinics - (University, Industry, Army, Navy & Other)	$29,000	7,790	16,000	210	5,000
TOTAL	$3,656,000	2,885,790	509,500	181,710	79,000

Source: CCMC (1932), Table 5, page 14.

Patients and families paid directly for more than ¾ of all expenditures. Physician services were the largest category. Hospitals accounted for less than ¼ of spending, and most were for long term care of mental and nervous disorders, disabilities or tuberculosis rather than care of

acute diseases (CCMC, 1932, p. 5). More than 1/5th was for retail sales of medical products, of which the majority was for tonics and elixirs that today would probably be banned by the FDA. Prescriptions were informal notes for patients to carry to a pharmacy as a suggestion for compounding rather than legally required. Insurance and prepayment were of great interest to the CCMC researchers, yet still so small they were lumped in with other hospital and physician fees rather than listed as a separate line item, even though funding for industrial clinics, accounting for less than 2% of the total, was deemed important enough to list separately.[12] Medicine had clearly begun the move toward complex modern organizational structures and financing, but only barely. Physician licensure was established in most states, but hospitals, pharmaceuticals, regulation and insurance were still toddling out of infancy and had not yet taken on recognizably modern characteristics or expenditure patterns.

1930-1955: Disruption and Consolidation. Along with the Great Depression and World War II, the next 25 years brought antibiotics, blood banking, cardiac pacemakers and other major medical advances, as well as substantial increases in the number and size of hospitals and the rise of employer based health insurance financing. What did not grow was the number of physicians relative to population. Medical care expenditures per person rose, but more or less in line with rapidly rising wages. A study of medical cost trends by J.R. Seale (1959) in *The Lancet* covering the years 1929 to 1956 concludes *"The proportion of the gross national product of a nation devoted to medical care tends to remain constant. It rises during national economic depressions and it falls during wars. A persistent rise in real per capita gross national product will tend to result in a very gradual increase in the proportion."* Based on Seale's Tables shown in **Figure 2** below, the cumulative annualized excess growth rate is 0.2% or 0.7% per year depending on whether the starting point is taken to be 1930 or 1929.

The Social Security Administration made attempts to provide comprehensive integrated national expenditure estimates at intervals (1935, 1940, 1950, 1955) before the current NHE Accounts were constructed in the 1960's. For the most part these estimates relied on the "personal consumption expenditure" estimates of compiled by the BEA and public expenditures series for the federal, state and local budget authorities, supplemented by data from the American Hospital Association, the American Medical Association, Blue Cross and Blue Shield. Lacking the resources of the CCMC to conduct original research, these compilations are only partly comparable. In particular, the growing use of third-party payment made the problems of double counting, cross-subsidy and shadow pricing increasingly problematic (see Appendix B).

Figure 2: from **J.R. Seale (1959). *The Lancet* no.7, 102, page 555.**

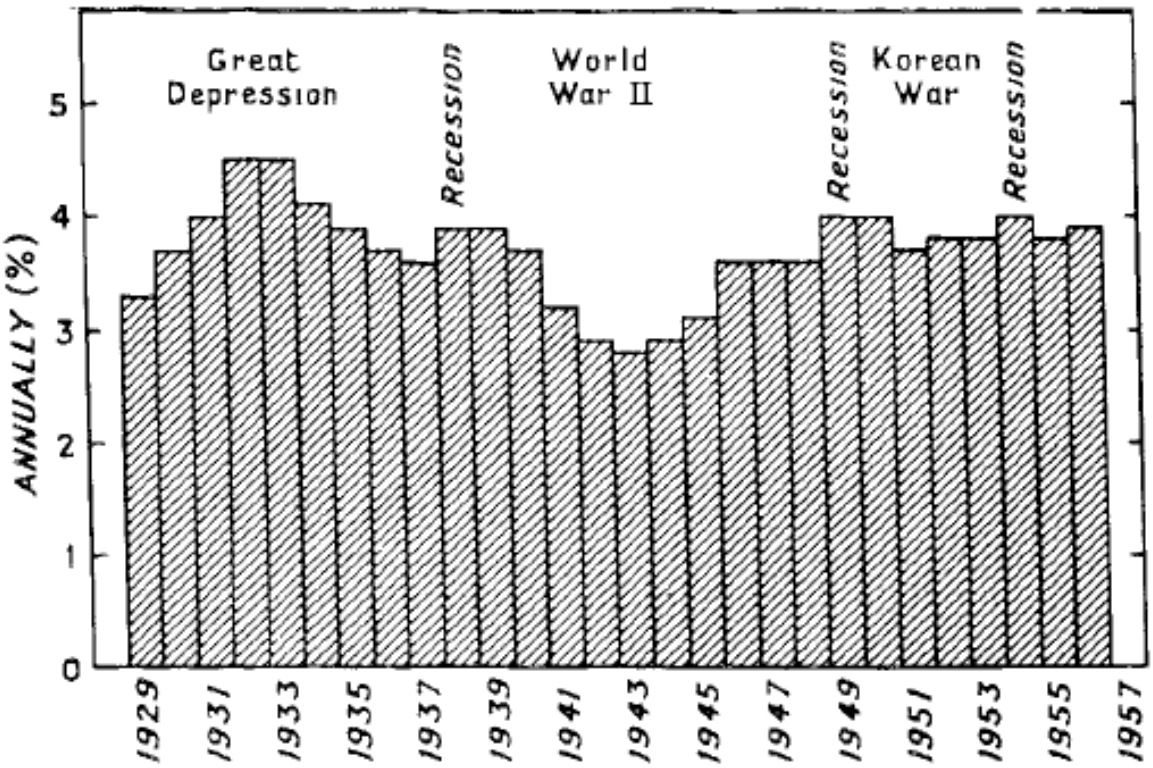


Fig. 2—National expenditure on medical care expressed as a percentage of gross national product, U.S.A., 1929–56.

These SSA estimates indicate an excess growth rate increasing the health share of GDP by about 0.4% per year from 1930 to 1955. The Census occupational data show that health care rose from 1.8% to 2.5% of total employment 1930-1950, an excess growth rate of more than +1.6% per year. Since this represented a major substitution of lower cost ancillaries for physician labor, it is consistent with a much smaller rate of excess expenditure growth, perhaps well below +1.0% per year (Dennison and Slater (1943); Weinfeld (1951); Numbers (1979)). George Stigler's (1956) extensive NBER study *Trends in Employment in the Service Industries* estimates 1950 health employment at 1.8 million, but does not appear to note any excess growth in the medical labor force, and indirectly implies growth in medical employment is no more rapid than in other service sectors—a sharp contrast to later BLS publications that termed health care a rapidly expanding "jobs machine" (Kahl 1986, Hiles 1992).

Each of the available sources yields slightly different estimates of spending and growth rates during this span. Considered together, they appear consistent with a 1930 level of spending

between 3.6% - 4.0% of GDP and annual excess growth rates averaging +0.1% to +0.9% per year. Despite disruptions from the great depression and WWII, average personal incomes rose by 3.3% per year 1930-1955, well above the long run rate of 2.1% or the 1.3% annualized increase 1910-1930, hence large increases in medical expenditures could be made without increasing the health share of GDP (Field 2003, 2011; Gordon 2016).[13] Imposition of licensure tightly restricted the number of doctors even though demand was increasing. The lack of physician supply response limited spending, as did the lack of access to capital for construction of new hospitals. Unlike the 1930s, the hospital of the 1950s needed operating suites, diagnostic laboratories, and trained assistants. Financial risks were transferred as insurance for major illnesses expanded to include almost half of the population, making access problems appear to be more a result of inadequate coverage than higher medical costs per se. Rising personal incomes, relief from the depression and post-war recovery, supply restrictions and the emergence of private health insurance were all factors that may have led commentators writing in the 1950s to express less concern over escalating medical costs than those writing in the 1920s or the 1960s.

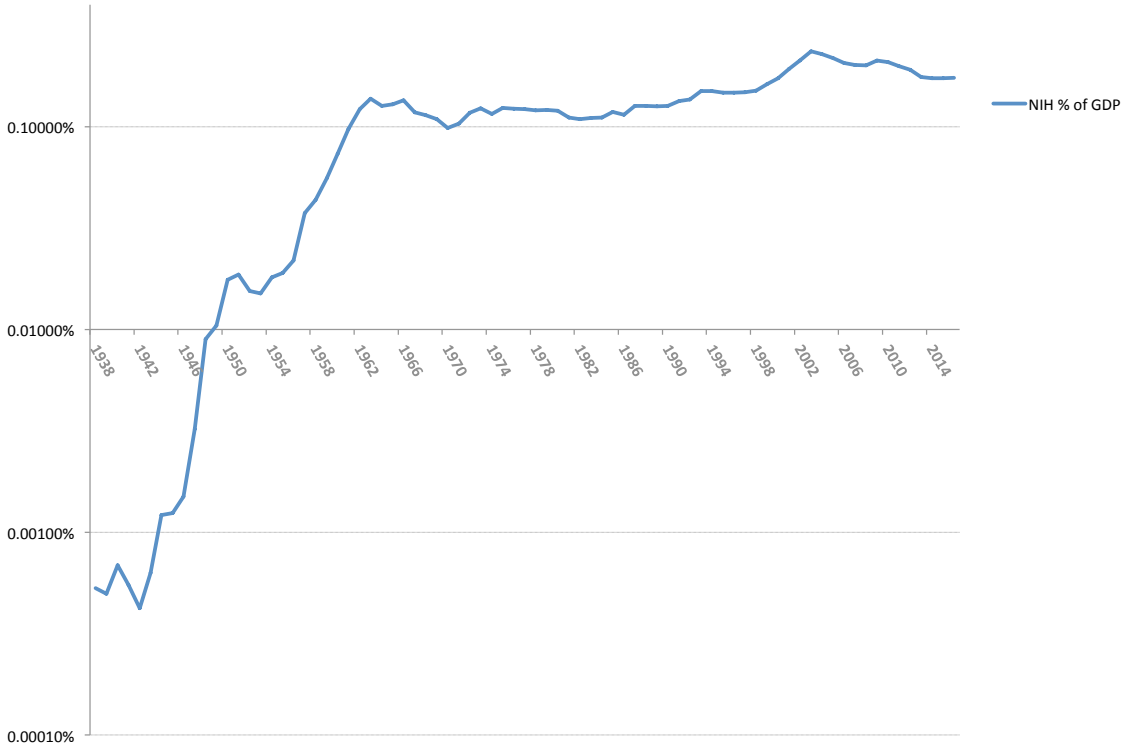
1955-1975: Investments in Science, Hospitals and Workforce Training Cause a Surge in Spending that Consolidates a *National* Health System. Rapidly increasing federal and state expenditures motivated the compilation of more detailed, reliable and consistent national health accounts in the 1960s. Tracing the flow of funds and subsidies for hospital construction, workforce training, medical research and the new Medicare and Medicaid financing programs became an operational necessity, justifying major efforts to refine budgetary analysis and accounting process. There are multiple data sources confirming that the 1960-1970 decade experienced the most rapid growth in a century. Specifying a single year when the surge started or slowed is more difficult and inherently imprecise.

"Technology" is the short answer often given for why medical expenditures grew so rapidly (further discussion in **Section V** below). A more nuanced and verifiable answer is that a surge of investments in medical research, hospitals, and professional workforce training created new high-technology academic medical centers that developed and disseminated advanced (and expensive) clinical practices across the nation, a process facilitated by the national expansion of third-party financing networks to vastly increase the flow of funds into the health system.

Medical science and clinical practice clearly advanced during the first half of the century, but more as a result of individual initiative and philanthropy than an organized research and development program. The National Institutes of Health (NIH) had been founded in 1938, but

received only $464 million dollars, a miniscule 0.0005% of GDP.[14] By 1950, funding had grown 30-fold to a still rather small 0.017% of GDP (Figure 3). The level was approximately the same in 1955 but then tripled to 0.074% in 1960, and doubled again within three years to 0.14% in 1963 – after which funding grew more or less at the same rate as GDP for the next thirty years. Private research funding is more difficult to track, but appears to have followed a similar trajectory. Pharmaceutical firms that had been mostly chemical companies compounding pills or purveyors of propriety elixirs and tonics in the early decades of the century shifted to become scientific laboratories relying on long-term research and development of "ethical" drugs requiring a prescription from physicians by the 1950s.

Figure 3: U.S. National Institutes of Health Funding *% of GDP, log scale*



The effects of new technology are made apparent by the divergence of trends in the number of hospital beds and the cost per patient day (**Table 6**).[15] At the turn of the century, many hospitals were small additions connected to a physician's residence or large state mental and infectious disease institutions. By midcentury free-standing general acute care facilities accounted for more than 3/4^{ths} of hospital costs. Psychiatric and tuberculosis hospitals still had

Table 6: Hospitals: Beds, Days, FTEs and Cost per day, 1910 - 2015

	Hospitals	Beds per 1,000	% beds General	FTE per bed	days/ person	$ cost per day	in 2009 $	% growth real cagr
1910	*4359**	*4.7*	- - -		*.4**			
1930	*6719**	*7.8*	*41%*		*.7**	*$5**	*$60*	
1946	6125	10.3	33%	1.1	.9	$9	*$76*	*2%*
1950	6788	9.6	35%	1.4	.9	$14	*$102*	*7%*
1955	6956	9.8	35%	1.5	.9	$21	*$135*	*12%*
1965	7123	8.8	43%	1.9	1.1	$41	*$217*	*8%*
1975	7156	6.9	65%	2.5	1.2	$133	*$424*	*12%*
1985	6965	5.5	76%	3.1	1.0	$460	*$803*	*14%*
1995	6291	4.1	81%	4.3	.8	$967	*$1,284*	*12%*
2000	5810	3.5	84%	4.7	.7	$1,148	*$1,402*	*12%*
2005	5756	3.2	85%	5.3	.7	$1,522	*$1,654*	*5%*
2010	5754	3.0	85%	5.7	.6	$1,911	*$1,888*	*6%*
2015	5627	2.8	87%	5.9	.6	$2,277	*$2,070*	*5%*

Sources: AMA, AHA and HSUS—see note[15].

more beds and patients, but received a much smaller share of resources. The total number of beds per 1,000 population rose during the first five decades, then fell steadily after 1950. What continued to grow was the technological intensity and cost for each day of hospital care. In the first half of the century much of the care was custodial. Acute medical and surgical interventions that are now implicit in the term "hospitalization" did not become dominant until the second half of the century. The American Hospital Association has reported annually on the number of hospitals, beds, days of care, revenues and expenses since 1946. At that time, the average cost per day was $9, or 0.5% of per capita GDP. By 1955 costs had risen to $21 per day, 0.8% of GDP. Ten years later cost per day was $41, 1.1% of GDP, and by 1975 $133, 1.7% of GDP. The number of FTE personnel per bed grew from 1.1 to 2.5. Tuberculosis hospitals disappeared, as did many state mental hospitals. The medical universe began to revolve around large academic medical centers that trained most physicians, did most of the research, and were paid the most for each day of patient care. The era of high-tech high-cost inpatient therapeutics had arrived with force, becoming the main factor driving the health share of GDP upward. Costs per inpatient day

continued to grow rapidly for the next forty years, although the shift of surgery, rehabilitation and palliative care toward outpatient settings have made "cost-per-day" less and less meaningful as an expenditure metric.

Hospitals, doctors, dentists, pharmaceutical companies, laboratories, imaging centers and other entities supplying health care goods and services are counted as "users of funds" in the NHEA and commonly referred to as "providers." Allocations of government programs and insurance premiums are made to account for administrative and capital costs distinct from provider payments to avoid gaps or double-counting. Nearly half of total payments went to physicians at the start of the century, one-fifth for drugs, and one-eighth for hospitals.[16] Since 1950 hospitals have been the largest component, taking one-third of total funds. Physician services are one-fifth, and pharmaceuticals one-tenth. The top rows of **Table 7** are classified as "personal health care" in the NHEA and account for 85% of total expenditures. The bottom four rows are overhead not directly attributable to individual patient care. Administration and net cost of insurance has consumed a steadily larger portion over the last half-century, while the shares for investment spending on research and construction were cut in half, falling from 3% to 1.5% and from 7% to 3.4% respectively.

Table 7: Spending shares by provider category 1910 - 2015

Year	*1910*	*1929*	*1955*	*1975*	*2000*	*2015*
Physician	*42%*	30%	20%	19%	21%	20%
HOSPITAL	*13%*	18%	33%	38%	30%	32%
LTC	5%	6%	2%	9%	13%	13%
Rx Drugs	*22%*	18%	13%	6%	9%	10%
Dental & Prof	15%	17%	12%	7%	7%	6%
Other Med	4%	2%	9%	6%	4%	3%
Admin & Ins	-	?	3%	4%	6%	8%
Bldg & Equip	-	5%	4%	7%	4%	3%
Research	-	-	1%	3%	2%	1%
Public Health	-	3%	3%	2%	3%	3%

SOURCES: CMS (2017), Reed & Hanft (1955), Lough (1935), CCMC(1932), and author estimates.[16]

The trend of medical practice over the last century has been toward ever increasing organizational size and complexity (Cutler & Morton 2013; Moses et. al. 2013; Glied, Ma, Solis-Roman 2016). In 1900 the modal physician was a solo practitioner, receiving occasional support from a nurse or assistant. The relevance of solo practice dwindled as the practice of medicine became more complex. By 1970 there were 2 RNs and 7 other health professionals, aides and technicians for each doctor. Even though there were slightly fewer physicians per 1,000 population than in 1900, the proportion of total employment in the health sector had become four times as large (Table 3).

Supervising health professionals required more training and more organizational capability. The doctor's office was gradually replaced by a teaching hospital, which then morphed into grander "Academic Medical Centers" by 1970 (Dzau et. al. 2010; Washington, Coye, Feinberg 2013)). Research, teaching, community outreach and advanced patient care were all brought together in one organization, although rarely under one roof as the capital expansion was so extensive that medical campuses stretched over several acres and sprouted satellite clinics miles away. Even though national health accounts report physician and hospital spending shares that are almost the same in 2015 as they were in 1960, management and administrative costs kept rising as provider size has increased dramatically.

Expenditure categories that served well from 1950 to 2000 are somewhat less useful for prior decades, or for the 21st century. The distinction between physician and hospital, inpatient and outpatient, is becoming less and less meaningful. Transitions between home care, nursing homes, hospice, rehab, LTAC, and skilled nursing beds may be very important for reimbursement, but less so for understanding patient needs or therapy. Now that some states pay family members to assist disabled relatives, even the line between market and household production has again become porous. In order to understand and control future costs, it may be necessary to devise new accounting methods.

Patients and families were the original payers of medical expenses, with limited supplementation from philanthropic and government funds. New forms of financial intermediation were required as costs expanded from 3% to 6% of GDP. Health insurance was scalable, flexible and robust -- able to grow with the advancing technology and organizational complexity of medicine. Just as mortgages and credit cards transformed housing and consumer spending, health insurance transformed medicine. In 1929, third-party financing covered just one-fifth of total expenditures (**Table 8).**[17] Government programs for public health, veterans and infant care, state mental and infectious disease hospitals, and other activities accounted for 14%,

while 6% was attributable to philanthropy, industrial clinics, voluntary visiting nurse services and other private sources. Insurance payments were so small that they did not justify a separate line item in the CCMC report and were probably less than 2 percent of the total (see note 27). There are no comparable health spending accounts for prior decades, but it is likely that more than 90% came from patient fees while insurance payments were negligibly small.

Table 8: Payer Financing % 1929 - 2015.

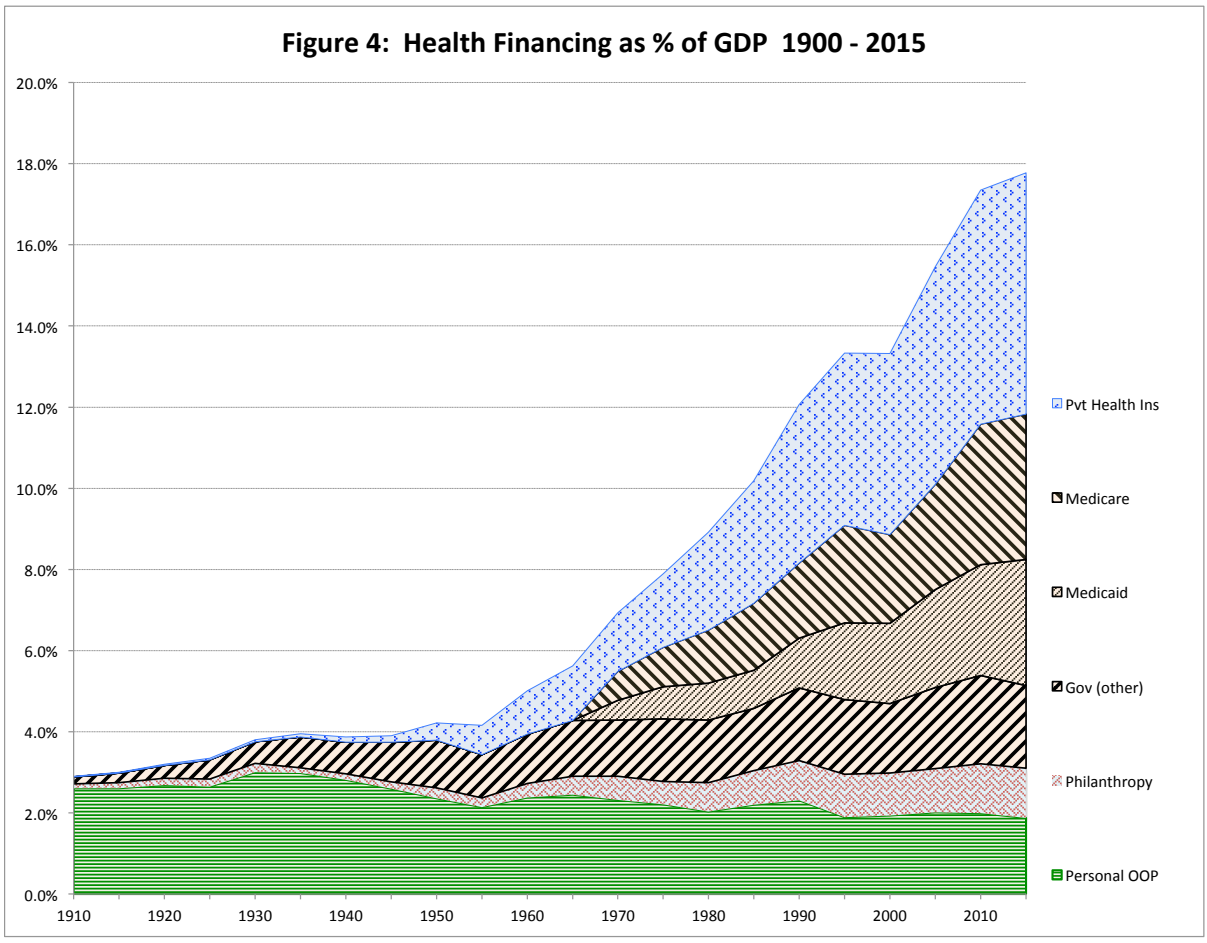
	1929	1950	1960	1970	1980	2000	2015
% with Insurance	*<3%*	*51%*	*72%*	*86%*	*89%*	*85%*	*89%*
Personal Pay (OOP)	**79%**	**56%**	**48%**	**33%**	**23%**	**15%**	**11%**
Philanthropy etc.	6%	6%	7%	8%	8%	8%	7%
Government	**14%**	**28%**	**24%**	**37%**	**42%**	**44%**	**49%**
Medicare				10%	15%	16%	20%
Medicaid, CHIP				7%	10%	15%	17%
Private Insurance	**1%**	**10%**	**21%**	**21%**	**27%**	**33%**	**33%**

SOURCE: CMS (2017), Health, United States (2016), 2016; Cohen et. al. (2009), Numbers (1979), Reed & Hanft (1966), CCMC(1932).[17]

Health insurance plans grew rapidly after 1929. Hospital expenses were most likely to be covered, with later expansions for physician services and dental visits. By 1950 more than half of all families had some form of coverage.[18] Coverage rose to 72% of all persons in 1960 and to 86% in 1970 after the implementation of Medicare and Medicaid. Coverage expansion stalled at that level. 14% of the population was still uninsured four decades later. With the Affordable Care Act of 2010, extension of insurance to more low-income persons without employer plans finally reduced the fraction uninsured below 10%. Personal payments from patients and families fell to less than 50% by 1960, under 15% by 2000, and are projected to be less than 10% by 2020.

By 1960 almost 3/4th of the population, 130 million people, were covered by Blue Cross and Blue Shield along with commercial insurance plans (Cunningham & Cunningham, 1977). However these private insurance plans provided less than a quarter of total funding (**Figure 4**). Government accounted for about one-quarter, but the largest portion, 48%, was still being paid for directly by consumers out of pocket. The passage of Medicare and Medicaid rapidly increased

the extent of coverage and government financing (Corning 1969; GAO 1976; Health Care Financing Review 2005; see also the discussion of financing patterns in Section V).



Source: see note 19

As third-party financing replaced personal payments national health expenditures rose from $27,214 million in 1960 to $74,563 million in 1970. GDP per capita was growing rapidly but health spending was growing even faster, with an annualized excess growth rate of +3.3%. During the peak years 1966-1970 the excess rate of increase reached +5.2%, sufficient to have doubled the health share of GDP in 14 years had it continued at that pace. Such growth was unprecedented and unmatched in any subsequent decade. The long period of post-war economic growth faltered in 1970 and then stumbled into stagflation and the OPEC oil crisis of 1973. Health spending continued to rise, but would never again reached the frenetic pace that occurred during the 1960s. After leveling out, growth became markedly slower toward the end of the century.

Administrative costs for private health insurance were high in early years, often more than 25% of premiums. They were reduced to about 15% by 1960, and fell below 10% by 1970. Since then increasing complexity has tended to offset the gains from scale, making administration consume about 12% of premiums over the last 25 years. Despite such overhead, tax deductibility renders the net cost of care to be less than 100% of nominal "price." More importantly, collective purchasing through insurance yields discounts. Persons buying medical care on their own behalf, the norm for most of the first half of the 20th century, are now so disadvantaged that they have become a small and disenfranchised minority.

Public insurance becomes financially important after the passage of Medicare and Medicaid in 1965. Private health insurance covers a larger number of people, but its financial role has declined as public insurance has taken on a larger share of burden (38% v. 33%) and Medicare has become the *de facto* standard for reimbursement, supplanting the Blue Cross and Major Medical methodologies that were most common from 1950 to 1980. Since almost 20% of "private" health insurance is for federal, state and local employees, and IRS regulations provide tax subsidies for the other 80%, government now accounts directly or indirectly for more than half of all national health expenditures. The share contributed by private employers peaked at 18% in 2000 and is now down to 15%. Household personal payments and premiums contribute 28%.[19]

The 20th century transformation of medicine was accompanied by a transformation of the health care financing system. It is not so much that insurance "caused" health expenditures to grow, as that a system of financing had to be built in order for health spending to grow, and once built, added momentum to rising consumer demand and technological advances (Weisbrod 1991; Peden & Freeland 1998; Smith, Newhouse, Freeland 2009). Health insurance became the dominant form of payment and combined with other forms of collective third-party financing now provides almost 90% of total funding for medical care.

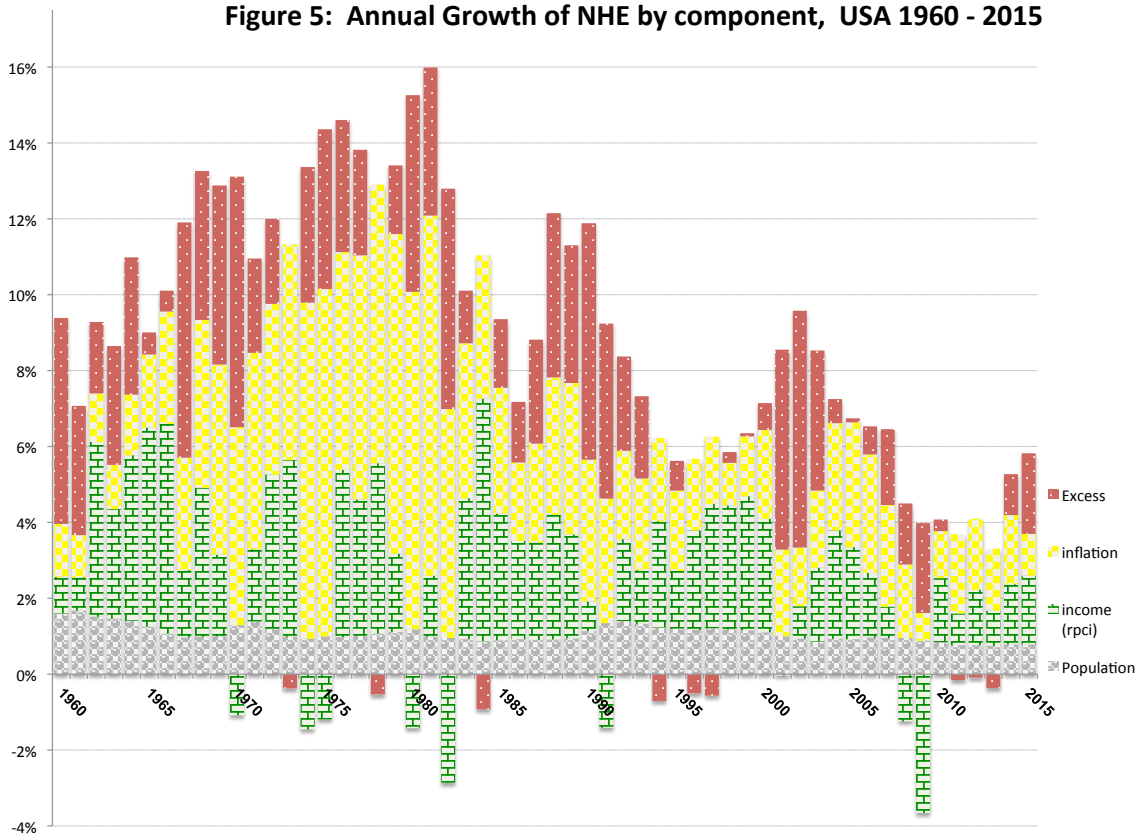
CMS OACT national health expenditure accounts are generally considered the gold standard for measuring changes in medical cost trends since 1960, yet they have been subject to numerous revisions, and it is acknowledged that the data for years prior to 1960 (1929, 1930, 1935, 1945, 1950, 1955) are not strictly comparable even though often included as if they were same as later years in the series.[20] BLS and Census employment data provide useful confirmation that 1960-1970 was indeed the decade of most rapid growth. The occupational category "health care" rose from 3.1% of the total employment in the 1960 decennial Census to 4.1% in 1970, an annualized share growth rate of 2.8% per year, well above the 1.6% per year 1900-1960 or 2.1%

1970-2000. The Bureau of Labor Statistics SIC employment health series starts in 1958 and shows health care rising from 2.9% to 4.3% of total employment 1960-1970, an annualized excess growth rate of +4.2%. A conclusion that expenditures were rising rapidly even before 1960 is supported by the excess growth rates in the first years of this series, +2.6% 1958/1959 and +4.6% 1959/1960. Excess employment growth in health care jobs decelerates to less than <2.0% after 1975 (although again accelerating during the early 1980's and late 1990's). The historical 1929-1970 Bureau of Economic Analysis personal consumption series shows medical share increasing modestly, less than <1% per year, before 1956, then accelerating above +3% during the late 1950's and continuing throughout the 1960's. Following the introduction of Medicare in 1966 excess growth peaked at more than +5% for the next four years, a rate sufficient to have doubled the size of the health sector relative to GDP in less than 15 years had expansion continued at that pace. The current OACT series estimates an average annual excess growth rate during the 1960s decade of 3.3%, much more rapid than the 0.7% rate for 1929-1955. Spending grew faster than employment as health care wages rose relative to other sectors of the economy. Excess cost growth continued to average above +3% per year after 1970 and then gradually fell (Figure 5).[21] Taken together, the available data sources establish that the decade 1960-1970 contained the most rapid expansion of health care in more than a century, and that this surge probably started before 1960 and did not begin to decelerate until after 1970.

After 1975: Bending the Cost Curve? The 1971 AHA manual *Budgeting Procedures for Hospitals* builds on an assumption that expanded insurance coverage meant most hospitals could easily exceed any reasonable operating requirements (AHA 1971). The manual even suggests that CFOs exercise restraint by setting charge levels well below what the market would bear, taking only the amount necessary to reach breakeven plus a small surplus. This assumption of unlimited access to funding was being eroded even as that manual was being published. Economy-wide price controls were established under the *Economic Stabilization Act of 1970* with special regulations for hospitals issued in September 1973. This legislation represents the first of many national efforts at health care cost containment. As with most price controls, the immediate jolt failed to bring about the desired long run results. The legislation was allowed to lapse in April 1974 before the planned *Phase IV* aggregate hospital cost controls could be implemented. The *HMO Act of 1973* had a goal of bringing cost control through more lasting structural changes in the health care industry. Although the HMO Act did not live up to that promise, portions of the legislation and its many amendments continue to live on in current law.

However inadequate and imperfect these cost-control rules and regulations were, their promulgation marked an end to the era of unfettered growth. Henceforth budgets would always matter, even if legislated limits on spending were frequently breached (GAO, 1976; Mays 2007). The pace of growth moderated during the decades after 1970, averaging 2.8% per year from 1970 to 1990 and 1.8% per year from 1990 to 2010. Year-to-year changes make it appear as if there were lulls or even reversals in the growth of the health sector during the 1970s and 1980s, but the apparent variation is due more to fluctuations in national income and inflation than to trends in medical spending (see **Figure 5** and "Temporal Dynamics" in **Appendix B**). For

Figure 5: Annual Growth of NHE by component, USA 1960 - 2015



example, from 1972 to 1973 the measured health share of GDP fell from .0723 to .0720, yet nominal spending rose from $93 million to $103 million, similar to the increases before and after. The 1973 "contraction" is a transitory artifact due to inertia in the health sector creating a temporal mis-match with measured income and inflation. An anomalous 11.4% increase in the denominator (GDP) made the relative size of the health sector appear to be declining. Measuring

share growth over more meaningful five- or ten-year spans around 1973 reveals cumulative annual growth rates in line with the long-run trend. Measuring excess growth relative to smoothed GDP yields an adjusted excess growth estimate for 1973 of +2.0%, just slightly below the twenty-year average.[22] The health sector may not have been expanding as rapidly in 1973 as it had been during the 1960s, but it was not shrinking. Similarly, the apparent lull in growth from 1982 to 1986 was primarily due to the lingering effects of the 1980 and 1981/82 recessions rather than any real slowdown in the rate of health system expansion. Since GDP was temporarily below trend in 1982, measuring health care as 10% of GDP for that year is misleading. This over-estimate in 1982 makes growth rates for the next few years appear artificially small. For the full decade 1980-1990 cumulative average excess growth rates exceeded 3% a year.

Business cycle fluctuations distort the measured health share of GDP, making it necessary to apply a time series filter, smoothing, or distributed lag analysis to clarify the adjustment process, an issue taken up at length in **Appendix B**. However, the spending restraint that kept measured health shares nearly constant at 13% of GDP from 1992 - 2000 does seem to be a result of real structural changes in health care rather than a reflection of macroeconomic fluctuations since there were no major shocks distorting income or inflation over this period. Although the 1993 Clinton legislation proposal for health care reform was not enacted, the threat of regulation and the impact of the 1997 *Balanced Budget Act* probably placed a check on expenditure growth. Even though a rebound after the turn of the century brought the health share above 15% by 2003, excess growth rates averaged just 0.8% for the next four years, providing more evidence that a real reduction in trend had taken place.

Assessing the slowdown in health spending since 2007 is more complicated. The relative importance of macroeconomic disruption and structural changes has already been debated at length by economists and in the media.[23] A headline that health spending grew "only" 6% in 2015 does not take account of the persistent decline in real incomes or the extraordinarily low rate of inflation. Disentangling these effects requires a more careful analysis of temporal dynamics.

4. Delineating Regime Changes and Trend Shifts

Growth of health care in the United States divides readily into three major phases; a long fallow period, decades of transition, then a modern era expanding within a structure that is more

or less stable. Medicine was an enduring but therapeutically ineffective economic presence for centuries. Employment in health occupations was relatively steady at 0.8% of total U.S. employment during the first thirty years it was measured (1850-1880) and then began to rise in the next decade -- a quantified signal of growth. The turning point from pre-scientific clinical nihilism toward early technological advances can be placed around 1910. The marker could arguably be put a decade or two before or after since the process of change was gradual and uneven, and since the difference between decades was less than the difference between urban and rural practices during this era.[24]

Transition to a modern health care system depended on three developments: *i)* national standards for medical practice, *ii)* institutional networks linking medical education and organization, and *iii)* broad financial support with national subsidies. The Flexner Report called for national standards of medical training including college chemistry, biology and physics as well as a hospital internship. During the 1920s and 1930s these educational requirements were incorporated in state licensure restrictions. Idiosyncratic judgments by solo physicians were slowly replaced by scientific therapies, but definition of what constituted "appropriate" medical care still relied on the judgments of local county medical societies. Mobilization for war in the 1940s regularized and routinized medical practice across the nation, helping to form a deep administrative structure. Provider organizations and health insurance replaced doctors working autonomously and receiving payment from individual patients. Hospitals and academic medical systems became powerful players defining what constituted good medical care. Yet ultimately it was the power of the purse that fused a truly national health care system. IRS regulations subsidized the growth of not-for-profit hospitals and private employer insurance plans in the 1940s and 1950s. Legislators provided the capital necessary for major expansion and took responsibility for financing a safety net ensuring care for the elderly, poor and disabled. Without Medicare and Medicaid certification (and funding) most hospitals and nursing homes could no longer survive. After 1965 segregated and substandard facilities were pushed into compliance as control over payment provided the power to enforce standards of practice and shape medical organization (DB Smith 1995). Although it was a patchwork system cobbled together from a path-dependent mix of public and private parts, health care in the United States became undeniably national after 1970.

Culmination of the transition phase can be placed within the span of a few years. Growth peaked 1968-1970 following a surge of expenditures powered by investments in capital structures, workforce training and research. Passage of Medicare and Medicaid legislation rather

quickly led to "almost" universal insurance coverage, supplementing the private health insurance plans developed over preceding decades. Access to advanced medical treatments became part of the social fabric—a much denser and richer social fabric now that Americans all had automobiles and either lived near a hospital or could easily drive to one. Life expectancy rose above the traditional three-score-and-ten. In *The Rise and Fall of American Growth* Robert Gordon (2017) identifies 1970 as a major turning point for the U.S. economy, and includes it as such in his chapter on medical care. The health care system continued to grow and develop yet remained recognizably similar for the next forty-five years --- a modern health care system with academic medical centers at the core, highly organized and regulated, with "almost" universal insurance coverage for more than 80% of the population that subsidized a safety net for the remainder. Marking major regime changes at 1910 and 1970, **Table 9** also indicates intermediate secondary periods when expenditure trends appear to have shifted.

Table 9: Eras in the Growth of U.S Health Expenditures

	I. Pre-Scientific		II. Transitional			III. Post-Modern	
	a) early	*b) late*	*a) early*	*b) formative*	*c) surge*	*a) early*	*b) present*
	1776 - 1880	1910	1929	1955	1970	1995	2015
H$/GDP	**.026**	**.029**	**.035**	**.042**	**.069**	**.133**	**.178**
growth rate		*0.4%*	*1.0%*	*0.7%*	*3.5%*	*2.7%*	*1.4%*

In 1929 the great depression disrupted the economy along many dimensions, including medical care. Yet technology continued to advance, saving lives and raising per capita incomes greatly over the next quarter century despite, and to some extent because of, World War II. Even though real per capita health spending rose faster 1929-1955 than it had 1910-1929, wages were rising so rapidly that the share of GDP increased only modestly during these years.[25] After transition to a modern national health care system was completed and growth peaked around 1970, the gradual deceleration in health spending was outpaced by a rapid decline in wage increases, resulting in excess growth averaging +2.7% 1970-1995. Since 1995, excess growth rates have been cut in half, although it is hard to point to specific technological, organizational or policy changes that can explain such significant deceleration, nor is there an expert consensus as to why the slowdown occured.[26] The forty-five years from 1970-2015 could be viewed as a single period during which health spending gradually albeit erratically wound down while the

institutional structures and financing mechanisms stayed mostly the same, or divided into two periods as is done here. Linkage between resource expenditures and regime change appears to be either very loose or subject to long lags.

5. Population Aging and the Allocation of NHE

In 1900 just 4% of the U.S. population were age 65 or older (65+), a share that doubled to 8% by 1950 and reached 12.5% in 2000. Offsetting demographic effects from the depression-era birth dearth and post-war baby boom kept the fraction 65+ relatively constant from 1990 to 2010. Since then it has risen steadily and is expected to reach 16% by 2020, moving above 20% by 2050 before stabilizing over the long run.

Even though the elderly were more apt to need medical care, the limited ability of families to pay for such care and the relatively small share of the population reaching advanced ages meant that only a small part of total health spending was attributable to older Americans during the first half of the twentieth century. The earliest survey with reliable age-related spending estimates was conducted in 1953. Average spending was $110 over age 65 and $67 under age 65, a ratio of 1.7:1 **(Table 10, Figure 6**).[27] 8.5% of the total U.S. population and 13% of estimated

Figure 6: Ratio of Personal Health Care Spending by Age 65+ / 0-64
selected years 1953 to 2012

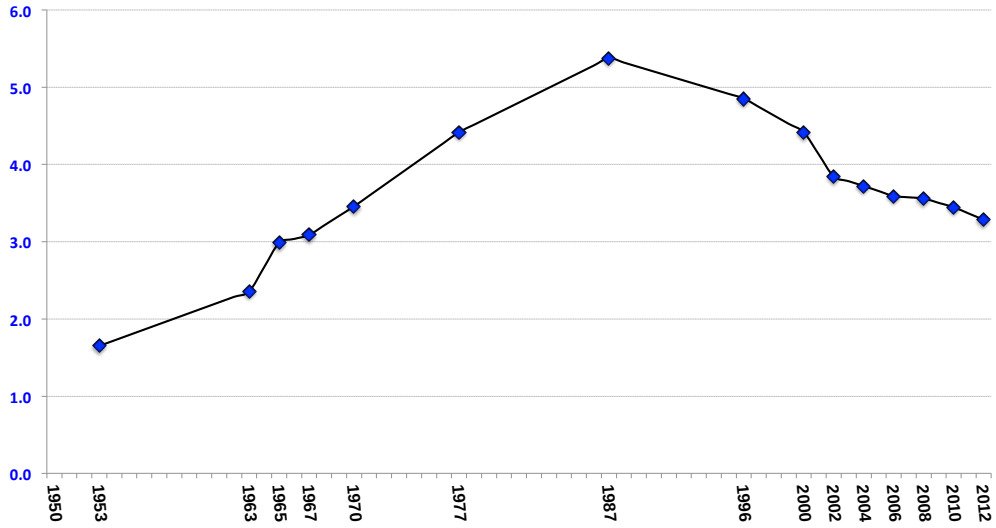


Table 10: Personal Health Care Spending per capita by Age

Selected years 1953 - 2012

	age 0-64	age 65+	ratio 65+ / 0-64	% pop age 65+	% spending $$ age 65+
1953	$67	$110	1.7	8.5%	13%
1963	129	304	2.4	9.4%	20%
1965	158	472	3.0	9.5%	24%
1967	171	528	3.1	9.8%	25%
1970	238	823	3.5	10.8%	30%
1977	453	2,002	4.4	12.2%	38%
1987	1,088	5,849	5.4	12.7%	44%
1996	2,123	10,308	4.9	12.4%	41%
2000	2,676	11,815	4.4	12.5%	39%
2002	3,521	13,537	3.8	12.4%	35%
2004	4,062	15,112	3.7	12.4%	34%
2006	4,577	16,434	3.6	12.5%	34%
2008	4,998	17,786	3.6	12.8%	34%
2010	5,381	18,544	3.4	13.1%	34%
2012	5,781	18,988	3.3	13.5%	34%

Source: Author calculations based on Meara, White and Cutler (2004); CMS NHE Age and Gender Tables (2017) and other sources.[27]

national personal health spending was accounted for by the older age group at mid-century. In the year 2000, 12.5% of the population was age 65+, the old/young spending ratio was 4.4:1, and the share of spending for older patients was 39%, three times as large as it had been a half-century previously. During the next decade, the ratio of spending for the elderly relative to the young declined to 3.3:1, reducing their expenditure share to 34% even though the percentage of the population age 65+ continued to age.

The share of GDP spent on medical care for the older population rises as the percentage age 65+ increases, as average per capita medical expenditures rise, or as spending per person on

the elderly rises relative to the young. Macroeconomic growth accounting decomposition is extended in **Table 11** to examine population age effects. Appropriately weighted, a sum across age groups accounts for the 85% of total national health expenditures classified as "personal health care" and the remaining 15% attributable to general overhead (administration, construction and research) can be allocated proportionately to provide an estimate for the share of GDP attributable to health care of the elderly. National health expenditures rose from $35 billion in 1963 to $2,795 billion in 2012, an average annual growth rate of 9.4% attributable to a 6.8% GDP growth rate (1% population, 2% real income per capita, and 3.7% inflation) plus an excess growth rate of +2.4% for the health sector. Only 0.3% of the overall increase is attributable to the elderly, +0.15% due to the rise in fraction of the population over age 65, and another +0.15% per year due to the relatively more rapid increase in spending per person over age 65 (ratio rises from 2.4:1 to 3.3:1).[28]

Table 11: Annual Growth of NHE by Age Group, 1963 – 2012

	1963 - 2012	`63 - 87	`87 - 12
Annual % Growth of NHE	**9.4%**	**11.9%**	**7.0%**
Population	1.0%	1.1%	1.0%
Inflation	3.7%	5.1%	2.3%
real per capita GDP	2.0%	2.5%	1.5%
Excess (Share growth)	2.4%	2.8%	2.0%
Contribution of population aging	*+0.3%*	*+1.3%*	*(-0.6%)*
Aging Effect Decomposition			
average $ growth 0-64	**2.1%**	1.5%	2.6%
change in % population 65+	0.15%	0.3%	0.1%
change in price ratio	0.15%	1.0%	-0.7%

Source: Author calculations based on Table 10. See note.[28]

In 1987 the elderly were 12% of the total population but accounted for 43% of total health spending. That share slowly declined for the next 20 years and then stabilized, but is likely to rise again in coming decades, and exceed 50% after 2050. The rise and fall of age-related health spending has not always been fully appreciated by analysts or the public. Since both the rate of growth in the share of population age 65+ share *and* the ratio of per capita spending by the age 65+ group relative to the rest of the population has varied over time, the estimated contribution of population aging depends upon the period chosen for analysis. During the span from 1963 to 1987 two-thirds of the increase in the health share of GDP from 5.4% to 10.6% was attributable to the over 65 group, twice as much as all the spending by patients age 0-64 combined (+3.4% v. +1.7).[29] After 1987 the older population actually reduced the average trend in per capita spending. Even though the fraction of the population age 65+ rose from 12.2% to 13.5% generating a rise in spending of 0.1% per year because older persons cost more, this demographic effect was more than offset by a relative cost decline. Expenditure per person 0-64 were rising so much faster that the old:young ratio of costs fell from 5.4x to 3.3x, reducing the trend by -0.7% per year. An "age wave" of costly health care swelled and passed. The rise and fall were primarily a result of policy, caused by changes in reimbursement, not a result of demographic changes or the incidence of disease.

Given that most of the rapid rise in medical costs during the 1970s and 1980s was attributable to spending for patients over age 65, it is not surprising that so many analysts intoned "demography is destiny" and attempted to explain rising expenditures as a function of population aging per se. Morris Barer and Robert Evans (1989, 1995) were among the first to point out that it was increased spending per elderly person, not aging populations, that was actually causing per capita expenditures to rise so fast. Subsequently Getzen (1992a) used OECD data to demonstrate that neither the level nor the rate of growth in percentage of population age 65+ was significantly correlated with international differences in per capita health spending care once income effects had been controlled for. More and more researchers reported minimal aging effects as observations were extended into the 1990s when the share of total spending attributable to the over 65 group had begun to decline (Reinhardt 2003; Chernichovsky & Markowitz 2004). Although the argument that aging is a major determination of national health spending is still sometimes heard, previous views regarding its importance have faded. However, the fact that retirees rather than workers or their children will eventually account for more than half of all patient expenditures still poses a major social and political conundrum.

6. Projections to 2026 and Beyond

Computationally and conceptually, long run projections of expenditures ten years or more into the future take the form of *GDP + X%*. The forecasts made by health economists and actuaries are conditional; given current population and macroeconomic projections and assuming medical technology continues to advance, then excess growth of *GDP+X%* per year is projected. The CMS Office of the Actuary (OACT NHE), the Congressional Budget Office (CBO), and the Society of Actuaries (SOA) routinely prepare and publish long-run national health expenditure projections, and all three have similar structure: a ten-year estimated share of GDP, an intermediate transition (termed a "step-down" period by actuaries), and an eventual convergence to *GDP+0%* since any other asymptote would make the model unstable by implying that eventually the health sector would consume the entire economy (or disappear).[30] Nominal spending amounts are heavily affected by macroeconomic inflation and income assumptions. CBO, CMS and SOA projections make use of the same sources, routinely documented in the *Medicare Trustees Report*, making it relatively straightforward to compare estimated excess growth rates. Minor differences do arise from the use of different data vintages, versions, revisions and updates for population, GDP, and historical health spending estimates. Those differences may create fluctuations in nominal yearly spending estimates but do not substantially affect the underlying projected long-run excess growth trend. In contrast to the standardized structure and comparability of long-run projections, short-term forecasts of spending for the next one to five years can differ widely in methodology and detail, often relying heavily on professional judgment or particular insurance benefit stipulations and reimbursement factors. Such specific factors and judgmental adjustments dwindle in importance over the long run. For a projection extending beyond a ten-year horizon it is the health share of GDP, the cumulative annualized excess growth rate, that matters. CMS and CBO estimates are mandated by congress to be "current law" projections and must of necessity focus on the Medicare and Medicaid populations and programs funded by the federal government. Those restrictions are very important for short-run estimates, and even for transitional trends, but meld into the overall average medical spending trend within a few decades.

Ten-year excess growth rates have averaged +0.9% to +2.7% for the last twenty-five years, providing the basis for a reasonable expectation that the trend will continue to remain within that range for the next ten years. Growth has slowed somewhat during more recent decades, albeit erratically, making it more likely that future increases will be toward the lower

end of the range. CMS has projected ten-year annualized forward excess growth rates of about 1.1% ±0.2% since 2009, with the most recent being 1.14% for 2015-2025 (OACT 2017b). Even if major structural changes in the health system were to begin next year, or had already started a few years ago, measures of expenditure growth from now until 2020 or 2026 might not reveal such a tectonic shift. Changes in average growth rates from +1.2% to +0.8% or to +1.6% might not be readily distinguishable from ordinary variation created by macroeconomic disturbances and random noise. Relative errors in the 2026 share projections are likely to be smaller than the errors in forecasting nominal or real GDP, or *post hoc* revisions to the present 2016 NHE estimate. Given the current budgetary outlook, the health share will probably fall somewhere between 18% and 23% of GDP which would be consistent with either random fluctuations around current trends or the early part of a new regime.[31]

At some point in the future, another major regime change will occur. It has been more than 50 years since the last transformation and, given the lack of public satisfaction with the current system, it could be argued that restructuring will come sooner rather than later. The next regime change may or may not coincide with a distinctive change in medical technology, but it will very likely be marked by and include a change in financing mechanisms and information technology. Average spending levels have risen from 5% of income in the 1960s toward 20% today, making private health insurance much less affordable to working families.[32] It is no longer just the poor who require subsidies, but also the median household with less than $55,000 to support multiple family members. Income growth appears to be declining and concentrated toward the top. Marginal productivity of medical expenditure appears to be falling. Every additional year of life expectancy gained seems to be more and more costly (Cutler, Rosen, Vijan 2006). Lifestyle, environment, exercise, inequality, family relationships and other social determinants are increasingly seen as more important for health than additional spending on clinical therapeutics. The design of health financing in 1965 focused on employer provided health insurance, with safety-net add-ons for the poor, the elderly and the disabled. In 2020, those add-ons will account for more than half of all expenditures. The old reliance on voluntary private insurance is not sustainable. The demise of defined-benefit employer pensions over the last two decades suggests weaker, not stronger, financial support from corporations.[33] Taken together, these changes in conditions and constraints over the last five decades would appear to make a further deceleration in medical expenditure growth more likely than a sudden acceleration.

7. Discussion

Economic development, demographic transition and the availability of therapies sufficiently effective to make a visible difference in people's risk of illness and death were all preconditions for the growth and transformation of medicine. These elements were complimentary, intertwined and reinforcing, yet tended to follow somewhat in the order presented: — gains in economic productivity providing the surplus necessary to increase survival and support scientific discoveries which then led to new clinical practices. Advancing medical technology fostered specialization, professional organization, the building of hospitals and higher costs of treatment, all of which required expansion of the payment system to broaden risk-pooling and finance continued progress. Medicare and Medicaid institutionalized and financed investments in research, workforce and hospitals after a surge of spending that had been initiated at least a decade before enabling legislation was passed in 1965; that is to say, they may be analyzed as endogenous changes rather than purely external shocks. They may also be considered the step that finally created a national health system for the United States.

How increases in GDP may lead to more or less proportionate increases in health spending is relatively easy to understand, as are the ways that advances in medical technology lead to more or less steady increases in the health share of GDP, and even how investments and construction of a modern national health system in the 1960s necessitated a one-time surge in spending. Less clear are the reasons why the health share of GDP remained relatively constant from 1930-1955 despite the manifold changes in medical technology and insurance, or what made spending grow so rapidly from 1970-1992 even though the current national health system had already taken on its present shape and changes in medical organization and financing appear to have been much less disruptive. One possible explanation is that there are long and variable adjustment lags of twenty to fifty years to accommodate major changes in economic activity or medical technology. That is to say, the great depression and other factors restrained growth for several decades after 1929, and that the upsurge in medical facilities, discoveries and workforce continued to push growth upward for several decades after 1968.

What is "Technological Growth? Long run macroeconomic growth in real per capita income appears to be primarily a result of advances in technology, increases in total factor productivity (TFP) measured as the residual by which growth in output exceeds growth in inputs. By construction, TFP includes gains due to improvements in organization, institutions

and the rule of law as well as scientific discoveries. Technological growth in medicine is similarly measured as a residual, a black box parameter representing the complex outcome of a mix of scientific and organizational factors.[34] When stating that growth in health expenditures is primarily a result of technological change, the residual referred to is usually excess cost growth after adjustment for changes in population, income, inflation and perhaps a few other factors, often presented as *GDP+X%*. A notable difference between TFP and "X" is that GDP and TFP purportedly measure changes in output, while "X" explicitly measures only inputs. The GDP deflator is more or less accepted as measure of aggregate price changes able to convert aggregate spending into real output units, but no such generally accepted index exists for medical expenditures.[35] The most widely accepted measure of health system output has been mortality, usually expressed in terms of life-expectancy or years of life gained, and presented with a number of caveats recognizing the limitations of such a crude measure.[36]

Investments in health care have been incredibly productive. Nordhaus (2002) estimates their value as being of the same order of magnitude as all of the gains in manufacturing and agriculture, and perhaps larger than the total increase in non-health goods and services over the 20th Century. It is also generally accepted that measurement of productivity in health care is problematic, so much so that it is conceded to be one of the main failings in TFP measures. BEA measured productivity of the health sector is low or negative for long stretches of time despite general perceptions of substantial improvements in medical care and rising life expectancy. This conundrum has perplexed economists and is not likely to be resolved at any time in the near future, but must be duly noted here.

How does "medical technology" grow? After a discovery such a bacteria, DNA, or immunosuppression is made, that scientific advance must be translated into therapeutic procedures.[37] This takes time. After a therapy is developed and refined in an academic medical setting, it must still be disseminated and incorporated into standard clinical practices in the community — and accepted for reimbursement by health insurance plans. "Technological" advance involves parallel streams of technical and organizational development. New science gives rise to new organizational structures (specialty societies, ambulatory surgical clinics) and financing mechanisms (major medical, DRGs, managed care). Studies of macroeconomic productivity and technological change by Paul David and others describe lags of multiple decades between discovery, dissemination and eventual growth in TFP and per capita incomes.[38] Hence lags of twenty to fifty years for medical technology and excess spending growth seem not

just plausible, but likely. Consider how difficult it is to temporally identify the measurable effects of major advances such as X-rays, antibiotics, organ transplants, gene splicing or cloning.

Temporal dynamics are made more complex by the role of expectations in generating behavioral change. Melissa Thomasson and Jaret Treber (2008) document how obstetric care and births began to move from the home into hospitals after 1915 based on a belief that "scientific" care was better, even though maternal and infant mortality was actually worse for hospital births until use of sulfa drugs became routine in 1937. Patient acceptance was based on expected outcomes, not actual results. Medicine, like many consumer goods and services, relies on perceived value rather than evidence (Tomes (2016), Dranove (2009), Cutler (2004). As long as the public believes that more and newer medicine is better, funding will be forthcoming. Some of the decline in excess growth rates after 1990 may have been due to increasing public skepticism regarding medical miracles (Illich 1979; Cutler and McClellan, 2001b). Faith in medical advances built up during the 1960s and 1970s by successes in cardiology, diagnostic imaging, SSRIs, statins and other drugs may have been shaken during the 1980s and 1990s by revelations of side effects, the failure of estrogen supplements in large randomized trials, and the AIDs epidemic, all contributing to lowered expectations and hence lower rates of excess growth over the last 20 years.

Investment, Insurance, Reimbursement and the Breakdown of the Voluntary Sector. While economic development and advances in medical technology are underlying factors that explain why spending rose, the more proximate and endogenous forces are financial: investment and insurance. Expensive new technologies created demand for third party payment, and the assurance of financing supported research to create new technologies.[39] Health insurance provided a mechanism to redistribute finances across time and persons somewhat analogous to the role of mortgages in the housing market. Yet much more was required of health insurance than mortgages had to do. Health insurance had to not only provide capital funding for investment and construction, but also to build human capital and fund research for new scientific discoveries. It had to redistribute resources from the working well to the sick and disabled, and also redistribute from the rich to the poor. It had to create certainty of payment in a turbulent high-tech market with great social obligations. Multiple objectives created strains within the healthcare financing system. Cracks appeared, were patched, and cracked again. Mechanisms that funneled billions and billions of dollars into the health care system tended to overwhelm the existing order. Eli Ginzberg (1984) decried "the monetarization of medical care" for creating

conflicts of interest that displaced professionalism and voluntary charitable not-for–profit institutions with what Arnold Relman (1980) referred to as the "*medical-industrial complex*."

In 1915, philanthropy and government were the third-party payers financing investment and subsidizing care for the indigent and the elderly. Charity, or at lest some form of sliding scale in fees, was a professional obligation of physicians and a mission of the voluntary hospital.[40] A bit of direct patient fees was diverted to fund these goals, but the needs were manageable and well accepted. This system held up for twenty-five years until being challenged by advancing technology and mobilization for World War II. Increasingly, medicine and hospital care were seen as necessities that should be available to all. By 1955 third-party payments covered half of all health expenditures. Direct out-of-pocket personal payments had actually fallen relative to wages for most families. Voluntary private insurance from employers, subsidized by a federal tax exclusion, covered 17% while government paid for 26% through a multitude of programs for veterans, mothers and children, the blind, the infirm and the indigent.

Rising demand and greater cost stretched voluntarism to the breaking point. Physicians no longer felt so obligated to provide free care or discounted fees to any sick person who appeared at the door unable to pay. Blue Cross and Blue Shield had to give up community rating that charged every family the same premium in order to compete with the experience-rated major-medical plans of commercial insurance carriers. Without cross-subsidies, hospital care was becoming increasingly unaffordable. Employer based health insurance from large companies was not available for the self-employed, small firms or the elderly. These coverage gaps were patched over by the passage of Medicare and Medicaid, providing somewhat adequate funding for another quarter-century, but the financing system became more and more stressed. Medicare and Medicaid had been designed as add-ons to complement a basically private system. Cost-reimbursement formulas developed by hospital associations were accepted for private Blue Cross patients, as was the usual, customary and reasonable (UCR) payment system developed by medical societies for Blue Shield. Yet by the end of the century it was Medicare and Medicaid, not private employer insurance, which paid most of the bills. Voluntary norms were replaced by regulation with administered prices; a Medicare prospective payment system using diagnosis-related groups (DRGs) was introduced in 1983, and a resource-based-relative-value-scale (RBRVS) for physician services in 1992. These became de facto industry standards as hospital chargemasters, laboratory invoices and doctor's bills became divorced from actual costs and less accurate reflections of actual transactions.[41] A distinction between "hospital charges" and "physician bills" baked into the Medicare reimbursement structure as part A and part B faded

toward irrelevance as independent doctors and hospitals gave way to large-scale health systems whose management was corporate even if they retained a 501©3 non-profit designation.[42]

Health insurance coverage of the population stalled at 86% in 1970, leaving 14% uninsured for decades (Cohen et. al, 2009). The contribution of employers to total spending peaked at 18% in the year 2000 and has since declined to 15%. The passage of the ACA in 2010 was a recognition that private voluntary financing was no longer a sustainable as the primary source of medical funding. Quick coverage increases were obtained by expanding Medicaid and creating new subsidized state health insurance exchanges for individuals. Quick cost reductions were obtained as the great recession depressed health care along with the rest of the economy. The long run consequences of ACA legislation are still unknown, as is the continued status of the law itself.

Path dependence and historical accidents played significant roles in the evolution of the U.S. health care system, but the fundamentals of advancing technology and rising costs drove the process. A shift to third-party reimbursement became necessary when technology, especially hospital surgery, became effective and expensive enough to require pooled financing. At 3% or 4% of average income, insurance was affordable to most middle-class families. When the share of wages required for health benefits quadrupled to more than 15% the median household could no longer afford coverage on its own. A voluntary safety net was no longer able to cover gaps in the system as more and more working families became "medically indigent."

The process by which voluntarism breaks down is well illustrated by two recent examples, hospice reimbursement and specialty drug pricing. Hospice began as a caring social movement, an attempt by concerned families and health professionals to provide death with dignity and ease pain by allowing terminal patients to die at home. At this early stage almost all of the labor was voluntary—if providers were paid, it was indirectly as they were compensated for "medically necessary" services that had a curative rather than palliative goal. Increasing acceptance and awareness that hospice was much less expensive than desperate attempts at curative therapy led to the addition of hospice as a Medicare benefit in 2004. With more money available, more professional providers stepped in. What had been a loose group of voluntary community groups was quickly transformed as commercial for-profit chains took over. Financial abuses mounted, leading to stringent controls and bureaucratic oversight. Fraudulent billing practices led to major fines. Within a short time, hospice reimbursement had gone through a financial cycle similar to that which had previous taken place for home health care, nursing homes, and hospitals.[43] Voluntarism, where charitable institutions are trusted and norms are

followed, is disrupted by an influx of new insurance financing that soon gives rise to a series of commercial abuses, which then lead to regulatory controls and complex administered prices. The loss of trust in physician charges over time shows similar dynamics. The most egregious current examples involve the pricing of generic pharmaceutical products such as epi-pens, daraprim, digoxin, pravastatin, and so on.[44] With media exposés and increased political attention it is unlikely that voluntary pricing allowing pharmaceutical firms to set unrestricted charges for reimbursement will continue much longer.

Deterioration of the voluntary sector may have brought the U.S. healthcare system to a point of crisis in the 21st Century. The investments and charity care required to sustain the system are harder to obtain from voluntary contributions when per capita costs exceed 15% of income.[45] Philanthropy continues, but as a smaller fraction of a growing total. Hospitals continue to provide some charity care, but not three times as much as in 1950. Employers, after replacing defined benefit pension plans with capped 401k contributions, have now moved to shift the risk of medical cost increases to employees through capped contributions to "consumer-driven" plans with large deductibles and copays. Competitive pressures do not allow private health plans to increase premiums in order to cover investments and services for people outside of the insured group. The system buffers and safety net once provided by voluntary norms have eroded and are being replaced by regulation and taxes.

International Comparisons: OECD data. Comparison of patterns in the U.S.A. with other nations is beyond the scope of this review, but it is worth briefly noting expenditure trends relative to major OECD countries. The discoveries and practices that initiated changes in the U.S. at the start of the 20th Century came mostly from Europe, as had much of the population and economic organization.[46] Innovations and organizational sophistication that accompanied the period of peak growth in national health expenditures during the 1960s, however, were generated internally. America had become the leader, rather than a follower, within a span of fifty years.

In a series of publications for the World Health Organization, Brian Abel-Smith (1963, 1965, 1967) observed that the USA spent roughly same share of GDP on health as other developed countries in the early decades of the 20th century, then rose to 30% above the average by 1960 (4.7% v. 3.6%). Expenditure shares in the USA remained 25%-35% above the OECD median for the next 20 years. During the 1980s the gap widened, exceeding 160% after 1990.[47] The 2008 global recession strongly reduced expenditure trends in England, Germany, France,

Japan Australia and Canada as well as the U.S. (Morgan & Astolfi 2013). As of 2015, the health share of GDP in the U.S. was 170% of the OECD median (17% v. 10%). This divergence in national health spending between the USA and other developed countries is a major anomaly, one that has been addressed by many researchers but for which no consensus explanation has been reached. The lull that kept health expenditures relatively constant as a share of GDP from 1930 to 1955 in the USA appears to have occurred among OECD countries during that period as well. However, the twenty years of continued rapid growth after 1975 in the USA was not matched elsewhere. OECD median health shares expanded about +1% a year rather than the +2.5% in the U.S., accounting for most of the current accumulated 70% differential. A perception that extra spending has not brought commensurate extra value is spreading from researchers to policy makers and the public, suggesting that in future years steps may be taken to reduce this disparity.

8. Conclusions

A preliminary conclusion to be drawn from this empirical analysis is that time scale matters: monthly variations are different from annual variations, and annual variations are different from the long-run trend shifts occurring over multiple decades that change the health share of GDP. A corollary is that some method must be used to adjust for macroeconomic shocks and lags. It is also evident that the influences of technology, insurance, and medical organization cannot be fully disentangled from economic development. These factors operate over long and variable periods. Bacteriology, chemical synthesis, antibiotics, DNA, immunosuppression, gene therapy and other discoveries took decades to be translated into effective clinical therapeutics and incorporated into insurance financing mechanisms. The great depression, post-war boom, and stagnation of wages after 1980 also affected spending growth for many years, as did the advent of Medicare and Medicaid. The relatively stable health share of GDP 1930-1955 and the rapidly rising share 1970-1992 make it plain that neither the rate of technological development nor structural changes in medical organization are contemporaneously correlated with excess spending growth. If there is an underlying connection between economic productivity, expenditures and regime change in medicine, as seems likely, it must be accepted that it usually occurs over many decades.

Health care grew slowly and erratically from the founding of the nation in 1776 until about 1880, differing greatly between urban and rural areas, across regions, and across income

quintiles. During the 19th Century there were substantial advances in population and per capita income, but not in medical practices or expenditure share. Scientific discoveries and clinical therapies from Europe inaugurated a rise in spending and reform of medical education by 1910. For the next twenty years medical technology continued to advance and spending outpaced income by 1% a year or more. After the 1929 depression, rapid per capita income growth enabled per capita medical spending to grow rapidly even as the health share of GDP remained almost constant, supporting development of voluntary private health insurance plans along with well-funded research centers. Investments in hospitals, research and workforce, followed by the passage of Medicare and Medicaid, pushed excess spending growth to +3.5% above the rate of GDP growth during 1955-1970 as large scale academic medical centers were built and a national U.S. health care system that encompassed most (but not all) citizens was created. The 1965 legislation was endogenous, more the fulcrum of change rather than an external cause.

As the pace of macroeconomic growth slowed in the decades after 1970, calls to control medical costs accumulated. However, spending still increased faster than per capita income by +2.8% from 1970-1990. Eventually excess cost growth was reduced, averaging a more sustainable +1% to +1.5% above GDP from 1993 to the present. Although there have been many subtle shifts and adaptations over the last five decades, modern medical care in 2015 is still recognizably close in form to the 1970 version, much more so than medical practice in 1970 was to that in 1930 or 1945. These generalizations and stylized facts are sufficiently supported by empirical evidence that any explanation or theory of long run health spending trends should be consistent with them.

Appendix A. DATA SOURCES AND EXTRAPOLATIONS

This appendix is used to document the source and data series used for each year within each table as well as some major disparities. There are usually multiple versions and vintages for each measure with considerable overlap across sources. Variance between versions, vintages and sources is inevitable, yet differences in estimated cumulative annual grow rates are usually small relative to disparities in initial or final levels. Abbreviations used here for the most common sources are listed below. All of these sources are well known and available online. Most data series are accessible in excel format and current versions were downloaded in September 2017 for consistency. All data tables are available in .xls format from the author upon request.

NHE – *National Health Expenditure Accounts, CMS OACT.*

HUS – *Health, United States, NCHS.*

HSUSm – *Historical Statistics of the United States –Millennial Edition (2006).*

HSUSc – *Historical Statistics of the United States – Centennial Edition (1976),* (pdf only).

BEA – *Bureau of Economic Analysis.*

BLS – *Bureau of Labor Statistics.*

Census – *Statistical Abstract of the USA.*

EMPL0YMENT

Occupational Counts in 18th Century U.S. Cities. A set of city profiles collected and coded by Peter H. Lindert and colleagues for estimation of American incomes 1650-1870 accessible on the "Global Price and Income History" webpage <gpih.ucdavis.edu> hosted by University of California-Davis provides the earliest data readily available for indirect estimation of health spending as a share of the U.S. economy. The 14 data sets cover 11 cities for single years spanning the period 1772 to 1806 (summary data provided in **Table A.1**). These profiles compile historical data. Information is taken from tax rolls, commercial directories, property listings and other sources. Each city profile is somewhat different, and in the three cases where two years are observed, there are substantial differences. They are not complete censuses or estimates of workforce or economic activity, although Lindert goes to some length to show how the data can be used to make such estimates as well as the assumptions and uncertainties involved. A brief review of the profile data for Philadelphia in 1800 here gives a sense of the kind of information available, while the complete data sets with notes and comments for all cities and years are readily downloaded by researchers interested in more depth and detail.

The 6,318 entries for Philadelphia in 1800 list 5,349 males, 683 females, and 286 firms. 158 of the men have no listed occupation, while 290 of the women are listed as gentlewomen, widows or unknown. The population of the Philadelphia was 41,220 in about 11,500 households. The 81 doctors include 68 M.D.'s, 1 surgeon, 2 physicians, 2 dentists, 1 surgeon-dentist, 4 bleeders, 1 surgeon-bleeder and 2 surgeon-barbers. 28 of the men are apothecaries & druggists, as are 7 of the firms. The most common female medical occupation listed is midwife with 8, as there is only 1 nurse identified. Thus of the total 6318 listings, 125 or 2.0% can be categorized as "medical." The boundaries of Philadelphia in 1800 included only the old city core of about one square mile where medical activity was concentrated, with some close-in neighborhoods such as Northern Liberties, Southwark or Germantown less than one or two miles from the current city hall excluded, as were all of more distant suburban towns. Since occupational listings in the Lindert city profiles cover only the more prominent half of the city population, and none of the remaining 90% living in rural areas, the listed occupational fraction probably overstates the

medical share of total workforce. On the other hand, there appears to be an undercounting of nurses and some other related occupations. Generalizing from the fourteen city profiles it might tentatively be said that medical care probably accounted for not much less than 1% nor more than 3% of the economy in these early years of the republic, was less common in newer and smaller western cities such as Pittsburgh and St. Louis, and slightly more prevalent by 1800 than in 1776.

Table A.1: Occupational Data for 11 U.S. Cities, 1772 to 1806

City	Year	all	% Medical	Doctor	other*
Baltimore	1799	2,913	1.5%	33	10
Boston	1800	3,656	1.5%	37	17
Charleston	1790	1,612	2.0%	29	3
Charleston	1800	1,993	2.8%	41	14
Hartford	1799	553	2.5%	8	6
Lancaster PA	1773	414	1.2%	5	-
Lancaster PA	1800	878	1.3%	8	3
Lexington	1806	266	2.6%	6	1
Norfolk	1801	798	1.8%	12	2
NYC	1799	6,926	2.5%	88	82
Philadelphia	1772	4,441	1.0%	34	11
Philadelphia	1800	6,318	2.0%	81	44
Pittsburgh	1815	1,362	0.9%	9	3
St Louis	1776	433	0.7%	3	-

*other = Druggist, Apothecary, Dentist, Nurse, Midwife

Source: Peter H. Lindert and Jeffrey G. Williamson, GPIH.ucdavis.edu (2017)

U.S. Census Occupational Tabulations 1850-1990. The U.S. census of 1790 did not collect occupational data, but starting with 1850 and decennially thereafter until 1990 it did, providing what the Lindert city profiles cannot – a national time series, now accessible as *HSUSm*-Tables Ba1033-Ba1439 (**Table A.2**). *Comparative Occupational Statistics for the United States, 1870 to 1940,* compiled by Alba Edwards (1943) for the Bureau of the Census and published in 1943, has become a standard reference, supplemented by the raw data from the 1850 and 1870 Census. Edwards focused on categorizing labor by skill level (professional, managerial, craft, manual) rather than industry. Estimates of "medical" or "health employment must rely on the analyst to judge which occupational categories should be aggregated. Classifications became increasingly complex and unsatisfactory over time as new occupations arose while older industrial and agricultural occupations declined in importance. George Stigler's 1956 NBER volume *Trends in Employment in the Service Industries* responded to the need for new measures, but continued relying on the old schema, considering "medical care" as a subset of "professional services" dominated by independent physicians and dentists at a time when hospitals were becoming the largest employers. While physicians constituted 80% of the medical workforce in 1850, by 1900 they were outnumbered by nurses and constituted less than

one-third of the total, a share that continued to decline to less than 10% after 1970. **Table A.2** relies primarily on the Matthew Sobek (2006) tabulation in *HSUSm* Tables Ba1159-1420. This data set is derived from the Census Integrated Public Use Microdata Series and provides the most consistent categorization, but lacks estimates for 1890, 1930 and for some occupations in 1940. These missing values have been extrapolated using the Edwards (1943) compilation and the Census 1900-1970 tabulation for the "economically active population" in *HSUSm* Tables Ba3688-4206. As the number of new medical occupations grows and hospital employment rises, the use of decennial census respondents' self-identified occupational labels becomes less and less satisfactory, shifting attention toward the Bureau of Labor Statistics data on employment.

Table A.2: U.S. Census Occupational Data 1850 - 1990

	All	Health		Physician	Pharm	Dent	Nurse	other
1850	5,277	52	**1.0%**	43	6	2	1	0
1860	8,161	89	**1.1%**	62	10	7	9	1
1870	12,004	104	**0.9%**	67	19	7	9	2
1880	16,479	153	**0.9%**	89	29	12	20	4
1890	21,423	222	**1.0%**	107	38	17	56	3
1900	27,554	395	**1.4%**	131	50	25	176	12
1910	36,236	509	**1.4%**	154	64	43	231	17
1920	40,113	599	**1.5%**	139	72	57	263	67
1930	43,777	891	**2.0%**	165	80	70	357	218
1940	47,584	1,044	**2.2%**	179	80	71	463	251
1950	56,974	1,420	**2.5%**	205	98	73	616	429
1960	63,871	1,973	**3.1%**	230	97	83	844	719
1970	76,271	3,063	**4.0%**	278	110	91	1172	1411
1980	97,378	5,209	**5.3%**	431	144	126	1831	2678
1990	115,083	7,108	**6.2%**	573	181	154	2533	3667

Source: Decennial Census, BLS, Alba Edwards (1943), HSUSm (2006)

BLS Annual and Monthly Employment Data 1958-present. The Bureau of Labor Statistics surveys firms to measure the number of employees.[48] BLS estimates are thus fundamentally different from individual responses to census takers regarding personal occupational status. A hospital administrator is "health care" by BLS employer classification, but a manager under Census occupational classification.[49] Conversely, a doctor or nurse working in a factory is classified as a manufacturing employee by the BLS but would be classified as a medical occupation by the Census. The BLS and Census not only rely on different classifications concepts (employer v. occupation), they also differ in the calculated size of the total workforce. For 1970 the BLS estimated 71 million total employees while census occupational counts totaled 80 million. Hence even though BLS health employment (3.1 million) was smaller than the Census

counts for medical occupations (3.3 million), the estimated health share of the total is larger (4.3% v. 4.1%).

BLS survey data extend back before 1950, but health employment **categories** only begin in 1958. These were initially based on Standard Industrial Classification (SIC) codes. The current BLS series is based on the North American Industrial Classification (NAIC) starting in 1990, with estimates from both NAIC and SIC classifications available during an overlap period from 1990-2001. Total U.S. employment estimates differ by less than 1% across the two series, but the changes in classification raised the estimated health share by more than 5%. The current series is downloadable in .xls format from the BLS website. The earlier SIC series for 1958-2001 is available in hardcopy or .pdf in the BLS *Handbook of U.S. Labor Statistics, 2003* with most of the years up to 1999 downloadable as .xls files in *HSUSm*-Table Dh206.

Table A.3: BLS Employment 1958 - 2016

	BLS Handbook (2003)		
year	All	Health	
	SIC	808	
1958	51,322	1365.2	
1959	53,270	1453.7	
1960	54,189	1547.6	
1961	53,999	1640.1	
1962	55,549	1739.3	
1963	56,653	1837.0	
1964	58,283	1963.0	
1965	60,763	2079.5	
1966	63,901	2204.2	
1967	65,803	2434.3	
1968	67,897	2638.6	
1969	70,384	2862.1	
1970	70,880	3052.5	
1971	71,211	3238.5	
1972	73,675	3411.9	
1973	76,790	3640.8	
1974	78,265	3886.7	
1975	76,945	4133.8	
1976	79,382	4350.4	
1977	82,471	4583.9	
1978	86,697	4791.6	
1979	89,823	4992.8	
1980	90,406	5278.0	
1981	91,152	5562.1	
1982	89,544	5810.8	
1983	90,152	5986.2	
1984	94,408	6118.3	
1985	97,387	6292.8	
1986	99,344	6527.6	
1987	101,958	6794.2	*BLS online (2017)*

1988	105,209	7105.4	All	Health
1989	107,884	7462.8	NAIC	65620001
1990	109,403	7814.3	109,527	8210.7
1991	108,249	8182.9	108,427	8617.7
1992	108,601	8490.0	108,802	8954.8
1993	110,713	8755.9	110,935	9253.6
1994	114,163	8991.9	114,398	9529.7
1995	117,191	9230.4	117,407	9808.9
1996	119,608	9477.9	119,836	10092.6
1997	122,690	9702.7	122,951	10358.0
1998	125,865	9852.5	126,157	10540.9
1999	128,916	9976.6	129,240	10690.9
2000	131,720	10103.4	132,024	10857.8
2001	131,922	10380.7	132,087	11188.1
2002			130,649	11536.0
2003			130,347	11817.1
2004			131,787	12055.3
2005			134,051	12313.9
2006			136,453	12601.8
2007			137,999	12946.8
2008			137,242	13289.9
2009			131,313	13543.0
2010			130,361	13776.9
2011			131,932	14025.9
2012			134,175	14281.6
2013			136,381	14491.5
2014			138,958	14676.5
2015			141,843	15042.3
2016			144,306	15420.4

Source : BLS Handbook (2003) BLS online data tables, 2017.

EXPENDITURES

Data on spending for 2016 back to 1960 is taken from the National Health Expenditure Accounts (NHEA) maintained by CMS Office of the Actuary, as are projections to the year 2026. Extending the current series back to 1950 is relatively straightforward since Reed & Hanft (1966) retroactively applied the NHEA structure created in 1963 to selected prior years, estimating NHE of $12,867m and $18,036m for the years 1950 and 1955. These are adjusted upward since the current 1960 NHE is +1.2% higher than their 1960 figure. Reed & Hanft estimate 1950 and 1955 health shares of GNP to be essentially constant at 4.5% of GNP, although they do not provide an exact amount for GNP. Using the current 2016 BEA estimates of GDP, the health shares shown in Table A.4 are 4.3% for both years. Even though GNP is slightly larger than GDP, the current GDP estimates are about 5% above pre-2000 estimates, raising the denominator and making the share estimates somewhat lower. It is clear is that the health share grew slowly if at all during 1950-1955, but very rapidly from 1955-1960, partly because health spending grew more rapidly, but mostly because real per capita GDP growth was so much slower (2.9% v. 0.8%).

Table A.4 National Health Expenditure estimates 1776-2025

	SHARE	NHE		GDP
2025	*.201*	*5,631*	*CMS OACT projections*	*27,987*
2020	*.187*	*4,198*		*22,415*
2016	**.179**	3,337	CMS OACT	18,625
2015	**.177**	3,201	NHE	18,121
2014	**.174**	3,026	Accounts	17,428
2013	**.172**	2,879		16,692
2012	**.173**	2,797		16,155
2011	**.173**	2,689		15,518
2010	**.174**	2,599		14,964
2009	**.173**	2,495		14,419
2008	**.163**	2,399		14,719
2007	**.159**	2,295		14,478
2006	**.156**	2,156		13,856
2005	**.155**	2,024		13,094
2004	**.154**	1,896		12,275
2003	**.154**	1,768		11,511
2002	**.148**	1,629		10,978
2001	**.140**	1,486		10,622
2000	**.133**	1,369		10,285
1999	**.132**	1,278		9,661
1998	**.132**	1,201		9,089
1997	**.132**	1,135		8,609
1996	**.133**	1,074		8,100
1995	**.133**	1,022		7,664
1994	**.132**	967		7,309
1993	**.133**	917		6,879
1992	**.131**	854		6,539
1991	**.128**	788		6,174
1990	**.121**	721		5,980
1989	**.114**	644.770		5,658
1988	**.110**	579.278		5,253
1987	**.106**	516.520		4,870
1986	**.103**	474.686		4,590
1985	**.102**	442.900		4,347
1984	**.100**	404.995		4,041
1983	**.101**	367.809		3,638
1982	**.100**	334.044		3,345
1981	**.092**	296.155		3,211
1980	**.089**	255.331		2,863
1979	**.084**	221.528		2,632
1978	**.083**	195.332		2,357

1977	**.083**	173.850		2,086
1976	**.081**	152.742		1,878
1975	**.079**	133.283		1,689
1974	**.075**	116.545		1,549
1973	**.072**	102.809		1,429
1972	**.072**	92.657		1,282
1971	**.071**	82.728		1,168
1970	**.069**	74.563		1,076
1969	**.065**	65.923		1,020
1968	**.062**	58.402		943
1967	**.060**	51.565		862
1966	**.057**	46.081		815
1965	**.056**	41.852		744
1964	**.056**	38.394		686
1963	**.054**	34.595		639
1962	**.053**	31.842		605
1961	**.052**	29.138		563
1960	**.050**	27.214		543
1955	**.043**	18.252	Reed & Hanft (1966) adjusted	426
1950	**.043**	13.021		300
1930	*.038*	- - -	*author est.*	92
1929	**.035**	3.656	CCMC (1932)	105
1920	*.032*	- - -	*author est.*	- -
1910	*.027*	- - -	Lough (1935) Lebergott (1996)	- -
1900	*.025*	- - -		- -
1880	*.023*	- - -	*author est.*	- -
1850	*.022*	- - -	Census occupations	- -
1776	*.019*	- - -	*author est.*	- -

Sources: See Appendix A.

Several series are available for the span from 1929 to 1950, all of which are anchored by the CCMC report. Their estimate of total health spending in the United States is expressed to four significant digits as $3,656 million "*… approximately $30 per capita, per annum, and in 1929 constituted about four percent of the money income of the country" (CCMC 1932, page 13).* Dividing this by the current BEA GDP estimate of $104,600 million for that year yields a health share of **3.5**%. This ratio is distorted by the severe macroeconomic fluctuations around 1929. The CCMC summary asserts "*…the data apply to the year 1929. They are probably representative of any normal year of recent times,*" *(page 14, note "a" to Table 5)*. 1929 was perhaps the least normal year of the century. Real income per capita fell in both 1927 and 1928, rose 7% in 1929, dropped -10% in 1930 and continued to fall by another -20% before 1932 when the final report was published. Price levels were also falling precipitously. Review of study procedures in volumes 6, 9, 10, 12, 14, 26, and 27 show that parts of the expenditure data collected apply to 1928 or 1930, and sometimes rely on estimates for which the exact period is unclear.

There was no standardized common measure of "GDP" in 1929. As a recent BEA guide notes *"prior to the development of official statistics in the 1930s, there were only fragmentary and sometimes conflicting data on the state of the economy."* (BEA 2016, pp.1-2). $103.5 million, as used in prior NIPA accounts, or the $104.6 million reported in the more recent tabulations, are reconstructions. Even for the year 2000, nominal GDP that was previously reported as $9,825 million is now estimated as $10,285 million due to revisions made by the BEA. The *"four percent of money income"* might refer to something like GNP or "disposable income" or "consumption expenditures" or some other concept. The source for the denominator is not clear from the text, but was not a stable or consistent amount precisely comparable to current measures of GDP. When the amounts in Figure 17 on page 117 of the CCMC final report are summed across categories, the implied health share is 4.5%. Different sections of the CCMC study variously place the share at less than 3.5%, more than 4.5%, or some intermediate value.

Consumption is generally less volatile than income, and medical care is even less volatile than most other spending. Given the drastic changes in income around the year 1929 and the inertia of expenditures, a reasonable case can be made for using a divisor based on incomes from 1928, or 1930, or an average of multiple years before or after. Accepting a numerator of $3,656 million, **3.5**% is probably closer to a lower bound than an average or upper limit. Long-run trend analysis is perhaps better based on a share estimate of **3.8**% for 1930, as used here in Table 3 and Table A.4. Although the CCMC report provides a comprehensive integrated estimate of total U.S. health expenditures stated to four significant digits, that number is not so exactly comparable to NHE in the current 1960-2015 CMS OACT series due to *(i)* business cycle distortions, *(ii)* ambiguity as to whether income and growth should be measured relative to GDP, personal income or consumption expenditures, and *(iii)* material changes in the U.S. health care system that largely replaced personal payments with third-party reimbursement and greatly increased the complexity of transactions.

Frank Dickinson, as Director of the Bureau Medical Economic Research for the AMA for many years, was instrumental in making better estimates of physician supply and incomes available for analysis. In addition, the AHA began providing data on hospital beds, occupancy and finances starting in 1946. The SSA *Compendium of National Health Expenditures Data* compiled by Cooper, Worthington, McGee (1973) covering selected years (1929, 1935, 1940) and then annually from 1948-1970 (available as *HSUSm*-Bd1) was able to make use of the Reed & Hanft analysis, the AMA and AHA data series, as well as the personal consumption expenditures (PCE) series in the BEA's NIPA accounts that include a sub-category for medical care divided in 8 items (available as *HSUSm*-Cd194-209). The *Compendium* is a compilation of available SSA data on public and private health expenditures, not an integrated accounting matrix. It does not have the detailed reconciliation across payers and providers or calculation of

subsidies and third-party transfers that is fundamental to the NHEA. The BEA medical care PCE is a product of the NIPA, not a health accounting system, and covers only 75%-85% of national health expenditures. Therefore the estimates for 1930 and 1940 in Table A.4 includes only estimates of the health share of GDP for 1930 and 1940, eschewing estimates of total nominal expenditures for those years as potentially misleading. Annual estimates in the *Compendium* and PCE often appear to be based on partial information or extrapolations rather than actual data for individual years, so only the estimates to two significant digits for decennial health shares are provided.

For the years 1900 to 1929, the only available expenditure series available are William H. Lough's 1935 volume *High-Level Consumption* covering selected years from 1909 to 1931 and Stanley Lebergott's 1996 *Consumer Expenditures* extrapolating the BEA PCE backwards to cover 1929 to 1900 in annual increments. Lough used a variety of sources to carry out what was, in effect, a partial set of national income and product accounts—an early attempt at macroeconomics before concepts and measures had gelled. It has obvious limitations, with the great strength of being relatively contemporary. Lebergott's book relies heavily on Lough's data and a series of linked regressions to extrapolate the BEA PCE series backward to reconcile the sum of all the consumption categories to some over- and under-estimates of medical expenditure with a net effect of making the medical care series rise very rapidly, 2.5% annually for 1909-1929 compared to 1.5% in the Lough series, a rate of excess growth that seems high, implying a doubling of the health share within a single generation when most therapies and medical organizations were still very basic. Medical employment grew 1.8% per year over that span, with the largest growth segment being nurses who earned less than MDs. Both the Lebergott PCE extrapolation and employment indicate that expansion of the medical sector during the first decade of the century from 1900-1910 was much slower than in subsequent decades. Based on a review of medical history and these three quantitative sources, it is here estimated that the excess growth rates were approximately 0.8% per year 1900-1910, 1.5% 1910-1920, and 1.8% 1920-1930, and these growth rates are used to extrapolate the health share of GDP from 1930 back to 1900.

There are other data sets such as the periodic Consumer Expenditure Survey (CEX) used to construct the item weights for the CPI, the NORC surveys of medical expenditures among a select group of about 1,000 families for 1953 and 1958, and more recently the large MEPS and HCCI data sets, yet none of these provides time series able to measure growth in aggregate medical cost over extended periods. Prior to 1900 the only available data series is that from the U.S. Census occupational data provided above in Table A.2. The decennial census occupational data begins in 1850, and there are no data series covering the 75 years following the founding of the United States in 1776. The Lindert city occupational counts make it apparent that medical resources were expanding in the late 18th and early 19th centuries –but were they expanding as rapidly as the growing population and incomes to make the share of the total economy devoted to medicine rise? Certainly in the cities, but probably not in the agricultural rural areas or in the new territories of Ohio, Tennessee and Virginia of the West. Contemporary accounts by doctors and the decennial census data for the last half of the 19th century make it appear that medical care grew at about the same rate as the other sectors of the economy, with perhaps an upswing during the final decade. The estimated rate of excess growth tentatively provided here and used in Table A.4 is 0.2% for 1850-1880 and 0.4% for 1880-1900. Information on medical incomes or prices for 1776-1850 is limited to anecdotes and sporadic reports for single towns or physicians, so any estimate for must be even more cautious, with 0.2% cumulative annual excess growth rate for these early years suggested and used here.

###

Appendix B. Measuring NHE: Budgets, Boundaries and Lags

Estimates of growth depend upon multiple measurements taken at different points in time. The official OACT estimates now available for all years since 1960 are generally accepted as reliable and valid, yet must be recognized as practical statistical constructs like "*GDP*" "*unemployment*," or *"the CPI."* Growth in health expenditures from 1960 to 2016 is not attributable to a single item or fixed bundle, but to a budget category as defined by a set of administrative procedures. A practical task facing actuaries at CMS is to craft acceptable measures that can distinguish enduring trends from transitory noise or arbitrary changes in the definition of what constitutes "medical spending." A task undertaken in this paper is to determine when stable growth trends shifted or became disrupted by major regime change. Analysis of the current 1960-2016 data reveals adjustment lags between macroeconomic shocks and health care spending that must be adjusted for to smooth GDP and filter out transitory fluctuations due to business cycles. Stretching analysis back before 1960 into the 18th and 19th centuries requires the use of more irregular and inconsistent observations, but it provides a vital context for understanding the scope and variance of 20th century trends, and also helps to expose the compromises, ambiguities and boundary disputes inherent in the measurement process that are still of concern even when analysis is based on the more regularized and refined national health accounts available today.

Boundaries

- *Household production* or market transactions?
- *Which* market transactions?
- *National,* regional, local, household or individual expenditures?
- *Nominal* or "excess" growth rates?
- *Compared to what?* (income, expenditures, consumption or GDP?)
- *Years, decades or moving averages?* Cash and accrual accounting, investment and lags.

Boundaries determine what is counted as "health" spending. The United States began as a largely rural and agricultural nation, with most labor devoted to household production rather than wage earning. Even by 1850 less than a quarter of the population was gainfully employed in the cash economy. There was a medical market with doctors being paid in cash (or in kind), but most care was provided by family members and neighbors. The shift from home to market production affects the measured rate of expenditure growth making the choice of an appropriate baseline to be used for comparison (total spending, total employment, total production or personal consumption expenditures) quite significant (Abraham and Mackie (2005); Moro (2017); NAP (2016)). Even after labor market participation rose during the 20th century and comprehensive national health expenditure accounts were developed, the boundary between market and household production remained ambiguous and somewhat porous for long-term care and mental health services.

The next boundary issue is the determination of which market transactions are counted as "health" spending. Obviously doctor and hospital bills will be included, but what about acupuncturists, spas or assisted living facilities? Are purchases of nutritional supplements, energy drinks, recreational drugs, exercise equipment, sleep aids, or ramps to accommodate mobility impairments included? In the 1932 CCMC report, 54% of the $665,000,000 spent on "drugs" was for un-prescribed tonics and patent medicines that the committee deemed purely wasteful, as was most of the $125,000,000 spent on faith healers and other irregular practitioners (CCMC 1932, p.15). During the late 19th and early 20th centuries the distinction between "costs of illness" and "medical expenditures" was blurred as many consumer

expenditure surveys tabulated a cost of "sickness" that included lost wages, worker's compensation and funeral expenses along with doctor and hospital bills. Uniform allocation requires that the sum across categories total to 100% in aggregate and within each division, requiring arbitrary distinctions and/or extensive cross-references. In his report on national medical cost trends, Frank Dickinson of the AMA contended that VA hospitals ought perhaps to be categorized as "defense spending" rather than "health care" (Dickinson & Raymond, 1955). In today's health marketplace, spending for home care, vitamins, herbal cures, yoga, counseling, wellness programs, and gym fees remain at the boundary of inclusion for reimbursement by health insurance or tax credits. Even after an accounting framework was established in the 1960's, attempts to match the sources and uses of funds in the NHEA to the NMCES and BEA estimates revealed significant gaps (Selden et al (2001), Sensenig & Wilcox (2001), Sing et. al. (2006), Bernard et al. (2012)). Discrepancies are often due to transfers (e.g., government funding routed through private insurance), double counting (e.g., by including both reimbursements and payments), cross subsidies (so that payments made understate true costs), rebates, discounts and biases due to sample selection. Boundary definition issues were greatly ameliorated by construction of the NHEA in 1964. More importantly, boundary changes have been documented since then facilitating recognition of discontinuities and calculation of reconciling adjustments. Major revisions have been made during the periodic updates of the NHEA, often raising or lowering estimates by more than 5% (Haber & Newhouse 1991; Fetter 2006; CMS 2009, 2010, 2015).

Urban and rural per capita spending levels converge over the long run, as do local and national growth rates. Yet during the late 19th and early 20th century development and access to current medical technology was very unevenly distributed. Dispersed farm families were inevitably left under-represented in survey samples even when they still constituted a majority of resident population. Measured trends may understate the rate of growth in aggregate national spending during this span since the broadening reach of social statistics brought in a changing mix of households. Average wage income, access to medical care, and substitution of market for household labor are all rising differentially as urban and rural populations converge. Starting at different initial levels of 1.5% (rural) or 2.5% (urban) will significantly change the measured rate of excess growth in aggregate health expenditures even as both populations converge toward the same 5% share in 1950. This mix variance may be of little concern if the analytical perspective is that of "comparing the growth rate of average per capita spending within the (ever larger) group having access to current medical care." However, in an era of uneven economic development, the sample mix does significantly affect the average per capita trend calculated for the nation as a whole. It is important to remember that even basic demographic statistics regarding birth and death rates similarly relied on small samples and did not achieve truly national coverage until the 1930s.

Boundaries for geographic aggregation that define valid units of observation for expenditure analysis are made problematic by the prevalence of third party insurance and government subsidies. Expenditures are made by transactions between payers and providers. The relevant fiscal entities are large organizations and federal or state agencies, not individuals. Financial flows are routinely recorded, reconciled, checked for consistency and accuracy and then incorporated in the construction of NIPA and NHEA accounts that maintain a fundamental additive accounting identity TOTAL EXPENDITURES ≡ TOTAL REVENUES. Only at level of the nation as a whole is this accounting identity consistently preserved. Smaller units (persons, households, neighborhoods/zip codes, counties, MSAa, HSAs, States, regions) have soft or undefined budget constraints so that allocations are dependent upon higher-level budget decisions rather than personal or local budget constraints. Medicare and Medicaid, as well as the determination of tax subsidies for employer health benefit plans, are dependent on national

policy and pooled funding rather than individual incomes or state revenues (Getzen 2000a, 2004).

Budgets: Spending as a Share of Income, Expenditures or GDP?

For the 19th Century, a health share is most commonly and reliably calculated as a fraction of the family budget, as a percentage of total personal consumption expenditures, or the percentage of employment in medicine and related occupations. This works reasonably well until about 1940 or 1950 when third party payments start to swell. The exclusion of taxes, savings and asset income does not matter so long as the proportions remain relatively constant—even though the levels may be different, the measured rate of excess growth over the long term is pretty much the same whether consumption expenditures, personal incomes or GDP is used as the denominator. Measuring health expenditures in nominal or real dollars, whether in total or per capita, presents major problems for long run comparisons. Since inflationary changes in the value of a dollar are expected to be neutral with respect to real resource use, meaningful comparisons require a deflator. Yet all of the available price index deflators are acknowledged to misrepresent the real rate of change to greater or lesser degree, with the errors being larger the longer the time span under consideration, and particularly problematic for personal services, and especially medical care.[50] The inherent advantage of measuring budget shares rather than dollar expenditures is that doing so normalizes spending relative to population, inflation and budgets (income). Only excess growth (*dH$ - dGDP*), the residual or "technology" effect, changes the measured share, not variation or errors in the number of persons, the number of dollars available to spend per person, or the real value of a dollar. Furthermore, excess growth is the primary concern of health policy. So long as expenditures expand at the same rate as wages and income, the health share of GDP remains unchanged and funding is not a problem.

Excess growth creates funding gaps and fiscal pressure. Population and general price inflation are presumed to be neutral, at least over the long run, and average income elasticity must asymptotically converge toward 1.0 lest shares go toward 0 or 100%.[51] While population growth or inflation or per capita income might have more than proportional effects on medical spending, any empirical evidence of such effects should become evident in the correlation between growth in these factors and the rate of excess growth. However, since GDP is more volatile than health spending, it is difficult to measure changes in share (ratio of Health $: GDP) over the short run. Changes over a few months or a few years are more often due to business cycle timing than variations in the long-run health sector growth trend. The use of adjusted lag filters or smoothing to ameliorate the econometric problems involved is explored at length in the section below on "Temporal Dynamics."

Trend estimates rely on boundaries that are stable but not rigid, measuring a categorical concept rather than a fixed bundle. Trend measures get distorted when there is a sudden change in definition, or by obsolescence as outdated technology remains in the sample while new procedures are excluded. The technological dynamism of medicine is challenging in this regard, forcing a trade-off between constancy and flexibility (somewhat analogous to the quality/quantity trade-offs or Laspeyres and Paasche Indexes). The practice of medicine in 1900 was sufficiently different from 1930 that distortions are inevitable. A hospital bed-day in 2010 is vastly more expensive and provides vastly more advanced services. The shift from inpatient to outpatient surgery complicates accounting, and covers knee replacements or laparoscopic appendix removal unavailable fifty years ago. The bundle of medical services is constantly changing, making any estimate of expenditure growth over long periods a conceptual stretch. Recognizing technological dynamism does not remove the need for a measure of growth in the use of resources, i.e. expenditures, even if comparisons over time are less exact than those for food, clothing, transportation or internet access. The data tabulated by Carroll Wright in 1880,

the CCMC in 1929, the BEA and the CMS Office of the Actuary in 1960 or 2016, all reflect the relative importance of health care in consumer and government budgets.

Temporal Dynamics: Seasonal Variation, Business Cycles, Inertia and Lags.

Analysis of trends in health spending (**H**) over the long run relies on measuring changes in the health share (**s**) of GDP (**Y**) rather than nominal dollar amounts or real per capita spending. Nominal comparisons across centuries are rendered almost meaningless by inflation and population increases. Even real per capita cost estimates, so useful for cross-sectional comparisons or evaluation of growth over short time periods, become problematic over decades. Income levels so strongly affect both supply and demand that underlying shifts in spending patterns are overwhelmed and obscured. Focusing on health share concentrates attention on the main policy issue, excess growth, and avoids the complexity and errors of multiple adjustments for population, inflation and income growth.

$$\mathbf{H = sY} \qquad d\mathbf{s} = d(\mathbf{H/Y}) = d\mathbf{H} - d\mathbf{Y} = \text{“excess growth”}$$

Unfortunately, volatility in the denominator (GDP) tends to add noise, distorting the measured excess growth rate (*% $Health - %GDP*). The health care system is inertial, responding only slowly to macroeconomic business cycles, with an average lag of three to six years (see **Table B.1**).[52] Smoothing GDP growth using a 6-year moving average of real per capita income and a 3-year weighted average of inflation provides a useful baseline. With smoothed GDP the time series fit of annual growth rates to GDP is fairly good (r^2 = .616), much better than the fit obtained using contemporaneous income and inflation (r^2 = .113) (see Figure B.1.a & B.1.b; Getzen 1990, 2014, 2016, 2017). Smoothing GDP removes cyclical and random noise making the underlying trends more apparent.

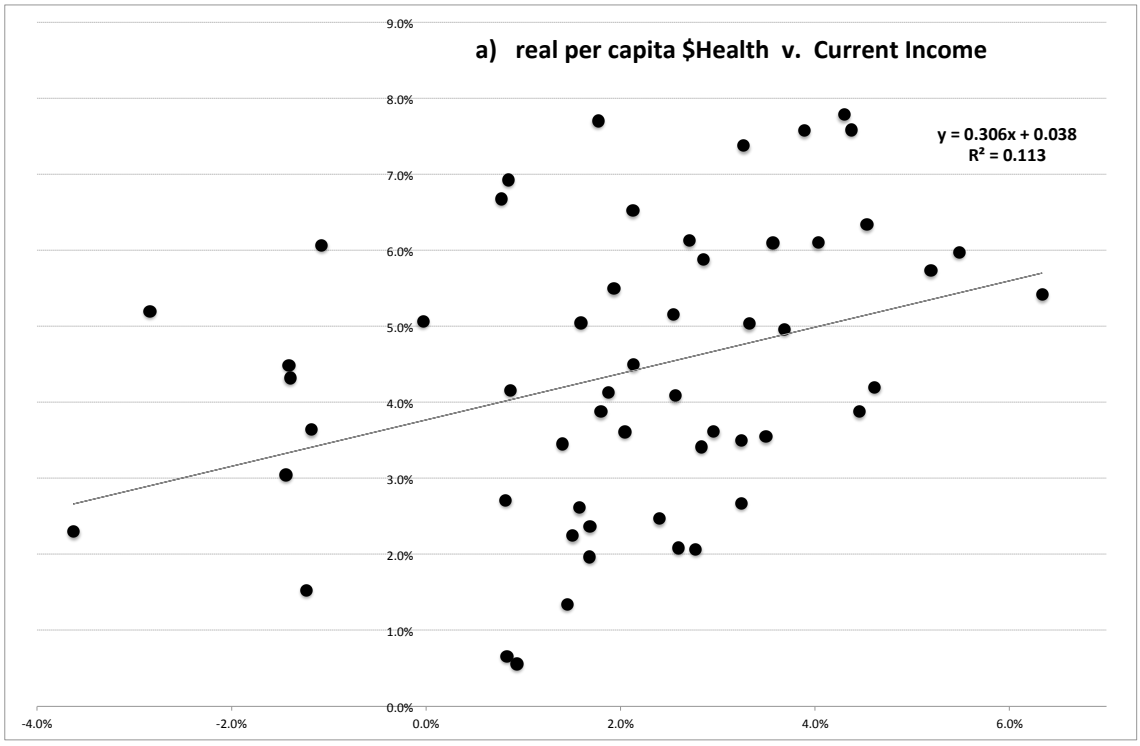
Table B.1. *Regression:* Growth in Real Health Expenditures (%) U.S. 1960 – 2015

	Constant	real per capita GDP growth						*Deflator*		Time	R^2
		year 0	year -1	year -2	year -3	year -4	year -5	year 0	year -1		
% growth NHE	.046	**.17**	**.07**	**.04**	**.19**	**.29**	**.23**	*-.28*	*-.12*	-.0006	**.702**

Source: Getzen2016a), author calculations.

The arrival of the great recession 2008-2010 made it abundantly clear that business cycles affect national health spending. In earlier decades multi-year lags made the delayed and gradual response of the health sector to macroeconomic disruption less visible. The possibility that structural rigidities in health professions and reimbursement create lags lasting much longer than the standard business cycle should also be considered, and is addressed in the “Discussion” section of the paper. Analysis of high-frequency monthly, weekly or hourly variations is precluded with national health expenditure data since the estimates are available only on an annual basis. However, the BLS employment series for health care is available monthly.

Figure 7: Annual Growth in NHE relative to a) Current Income b) Lag Smoothed Income



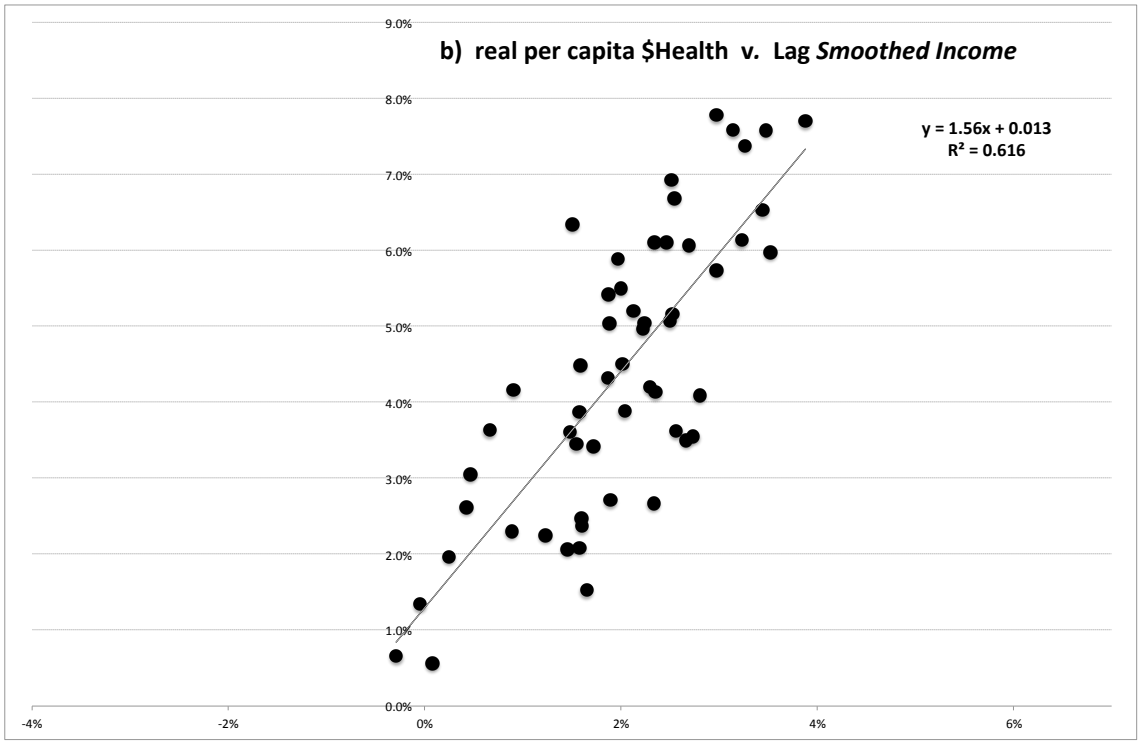
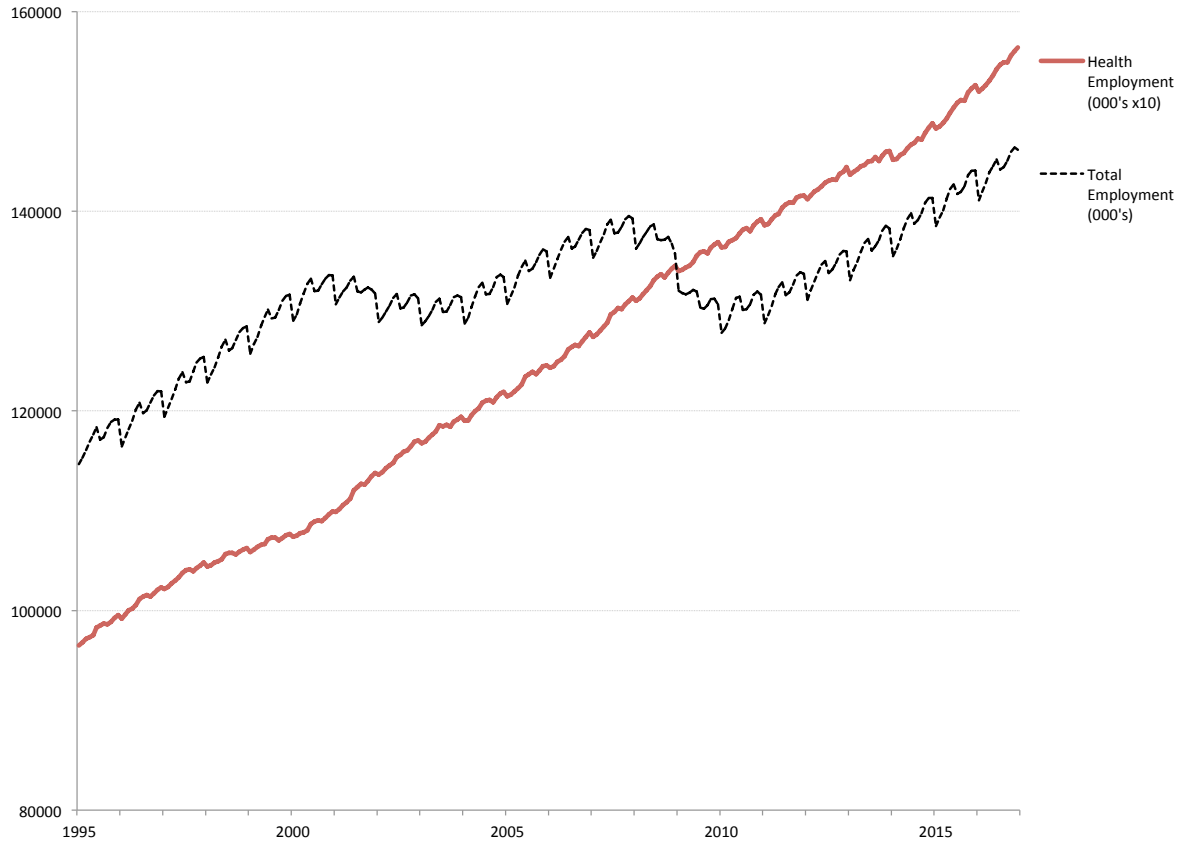


Figure 8a: U.S. Employment 1995 - 2016



Total employment is more variable than health sector employment as shown in Figures 8a to 8d. Figures 8b and 8c. show that monthly variation in health employment is not only smaller, but also has a different seasonal pattern. Using 12-month change rather than 1-month change, as in Figure 8d, makes the effect of the 2007-2009 recession very plain. Given sluggish macroeconomic response, high-frequency observations over short periods are not able to illuminate the dynamics of health system change and have noise that must be filtered out in order to determine trends or spot inflexion points marking phase transitions into a new regime. In order to reveal the dynamics of a process, the units of observation must be matched to the span of the phenomenon under investigation. Significant changes in health care organization take decades to develop, rather than months or days or even a few years. The long slow process is a major reason for extending analysis back before the start of modern OACT annual estimates in 1960 even though the data are more irregular, infrequent and incomplete.

Figure 8b: Monthly % change in Employment USA 2005 - 2016

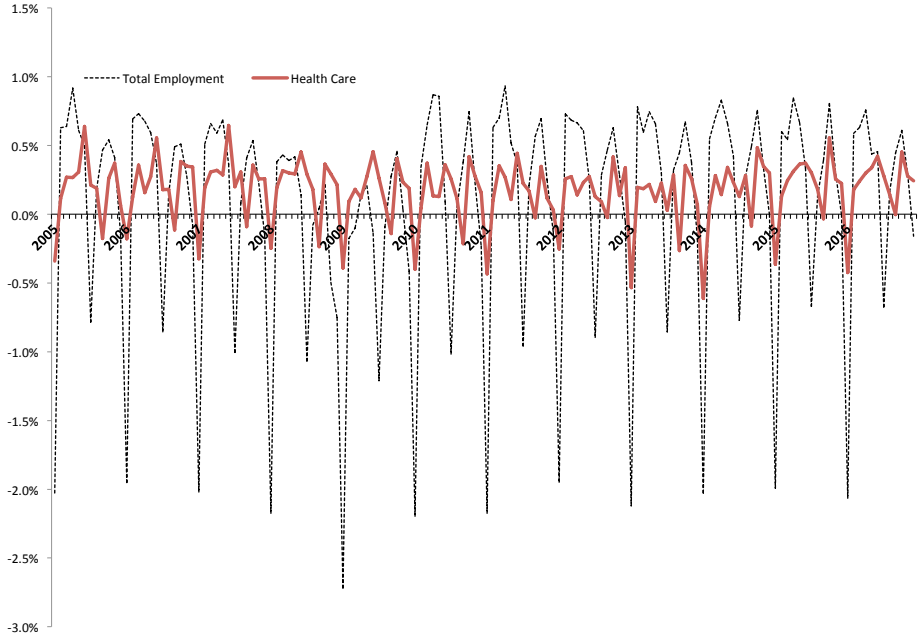


Figure 8c: Monthly Variation in Employment *(de-trended)* **1990-2016**

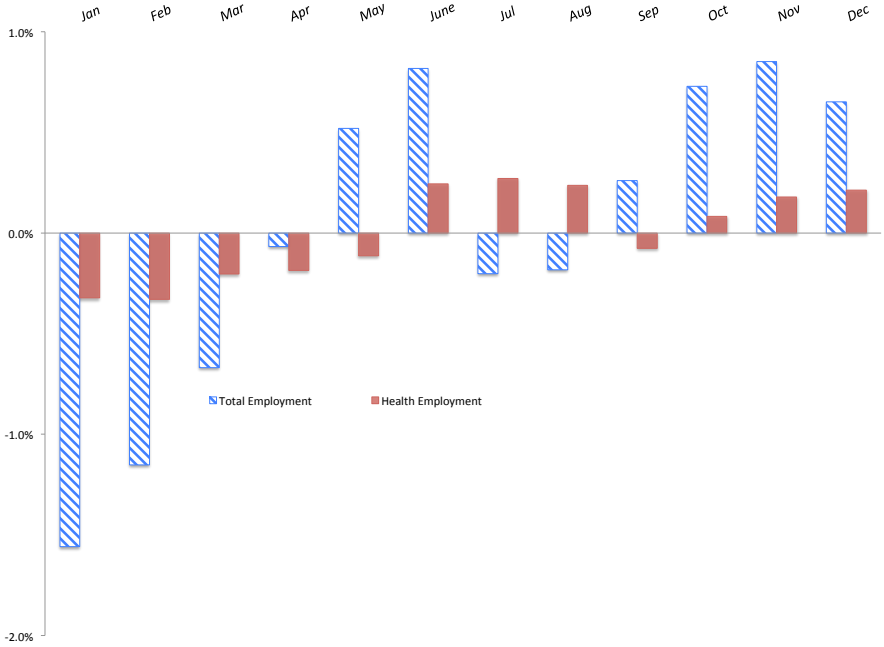
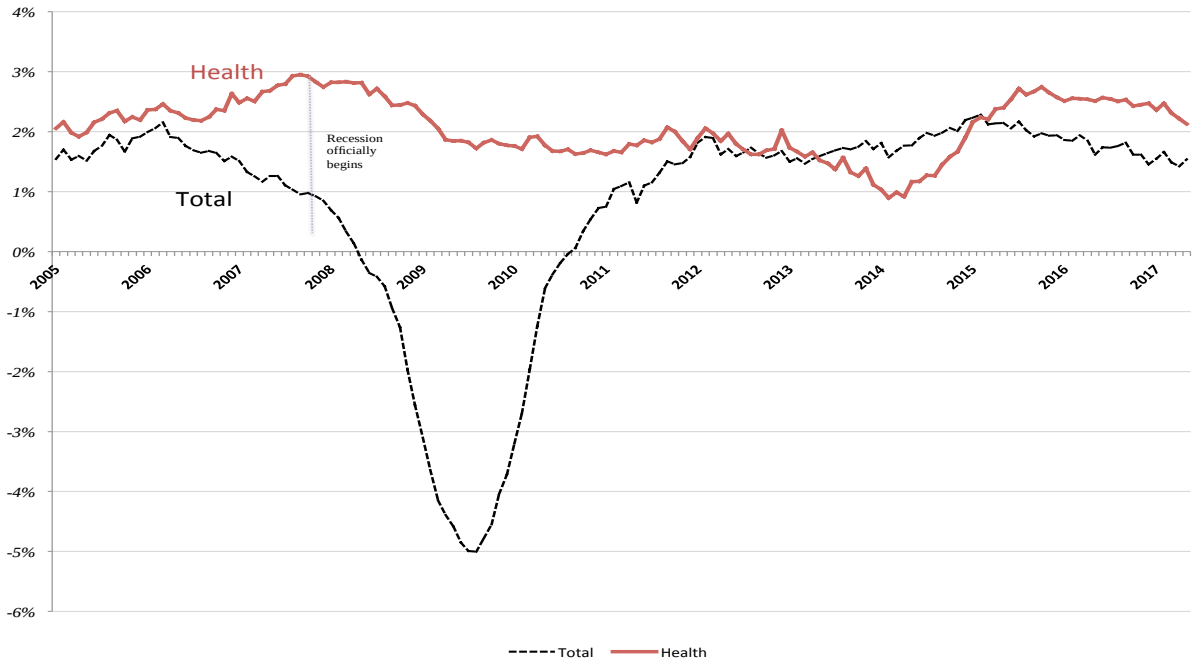


Figure 8d: Annual % Change in Employment: U.S.A. 2005--2017



Fluctuations in spending due to business cycles or periodic data revisions may complicate the analysis of trends, but they do not create them.[53] Long run trends that increase the health share of GDP are obtained by filtering out the baseline growth in population, inflation and per capita income, providing better forecasts and meaningful comparisons and over decades (Getzen 2000b, 2016a, 2016b). Random errors in any given year are to be expected. Every five to ten years there are revisions updating the definitions and boundaries of NHE that may change the total amount for a single year by 5% or more but should not substantially distort measures of trend so long as a specified version remains in force or is applied retroactively to obtain consistency with estimates for prior years. While smoothing, filtering or distributed lag adjustment can ameliorate the distortions due to macroeconomic shocks, residual timing errors can still displace estimated growth increments by one or more years, particularly for major shocks such as the inflation spike in the 1970s or the great recession after 2007. Reversals and recoveries over less than a decade should usually be considered transitory rather than enduring.

#####

Endnotes

1. See Table A.4 and description of sources, estimates and extrapolations in Appendices A and B. Excess growth rates are the annualized percentage increases in the health share.
2. Dublin (1927) also estimates that there are 50,000 dentists with similar incomes, 140,000 nurses doing private bedside work earning $1,500 per year, 150,000 practical nurses and 100,000 other employees of various kinds with average earnings of about $1,000 per year. He estimates that there are 27 million families in the U.S. spending an average of $80 per year for medical care. Thus Dublin attempts to reconcile the demand (expenditure) and supply (revenue) estimates in arriving at his total of "over two billion dollars."
3. See Bernard et al (2012), Hartman, Kornfeld, Catlin (2010), Machlin, Valluzi, Chevarly (2001), Selden, Levit, Cohen et al (1996), Sensenig, Wilcox (2001), Sing et al (2006), Zuvekas (2009).
4. There are many hundreds of studies of health expenditure growth in the U.S., and most are excluded from this review. Time series of less than twenty years are too short to provide robust evidence of changes in long-run trend that could meaningfully be related to changes in policy, events, technology, organization or macroeconomic conditions. Many studies use geographic sub-divisions in panels of that do not correspond to national trends. Also excluded are studies limited to determination of factor contributions rather than shifts in trend. The fourteen listed in Table 2 includes almost every study of long-run trend changes, with particular focus on studies from before 1990 that might not be as well known or readily available to most researchers. Also excluded are the many cross-national time series studies that do provide insight into U.S. national trend differences but were deemed outside of the scope of this paper in order to maintain a focus on the U.S. trends. It must be recognized, however, that the compilation of comparative international data sets by Jean-Pierre Poulier at the OECD (1977, 1990), WHO and the World Bank have transformed the understanding of U.S. trends, and also that the recent OECD study by David Morgan and Roberto Astolfi (2013) provided important evidence that major recessions do significantly affect spending trends in all developed countries.
5. Weisbrod (1991, page 529) also discusses how size affects interaction: Switzerland is small so research and medical spending are independent, while the USA is large enough to experience general equilibrium feedback between research and NHE.
6. This is the only detailed analysis of trend changes by the OACT team, although the annual NHE estimates published in the *Social Security Bulletin* (1960 to 1977), *Health Care Financing Review* (1978 to 2002) and *Health Affairs* (1988 to present) often include brief comments about trends or changes in trend.
7. Mokyr (1998) states "…the history of medicine, as viewed from the point of view of the technological historian, shows remarkably little progress of any significance before 1800. Indeed, it could be argued that the ability of mankind to understand, avoid, let alone cure diseases by 1850 was little better than it had been at the time of Galen [p.121]." See also Bryan (1964), Vogel & Rosenberg (1979), Rosen (1983), Warner (1986) Bynum (1994) Boustan, Bunten, Herey (2013).
8. Table 3: See Appendix A and B for more detailed discussion of sources and measurement issues. **National Health Expenditure** shares are from the current OACT series 1960-2000 and extrapolated back to 1776 as described in discussion of Table A.4. **Real Gross Domestic Product per capita** in $1996 from online Table Ca11 in *Historical Statistics of the United States* (2006) (*HSUSm*) for 1790-2000 and extrapolated back to 1776 using the 0.73% annual growth rate from 1790-1850. **Resident population** in millions from *HSUSm*-Ca14 (identical to Aa7) and extrapolated back from 1790 to 1776 using the 3.05% annual growth rate from 1790-1850. **Urbanization** *HSUSm*-Aa699-715 for 1790-1999 and "percent urban" for 2000 and 2010 at https://www.census.gov/geo/reference/ua/urban-rural-2010.html. **Physicians** from U.S. Decennial Census occupations 1850-1990 in *HSUSM*-Ba1218 & Ba1222 for 1970-2000 from *Health, United States, 1993* Tables 108 and 109, and *Health, United States, 2015* Table 83. **Health Employment** from U.S. Decennial Census 1850-1970 in *HSUSM*-Ba1033-1439 (occupations categorized as "health employment" by author), and for 1970-2000 from *BLS Handbook of U.S. Labor Statistics, 2003*,Table 2-1. See Appendix A, Tables A.2 and A.3 and Alba Edwards (1943) *Comparative Occupational Statistics for the United States, 1870 to 1940*. Employment estimates in the older BLS series are somewhat smaller than in the new series, which began in 1990, and also differ from census occupational totals 1960-1990. **Staff per MD** is total health employment (minus physicians)

divided by number of physicians. Note that various vintages or versions the "same" data series often show different values for the same year.

9. Lough (1935). The BLS also published a compendium of 19 workmen's budgets in for years 1920 indicating medical costs averaging 2.9% of working family expenditures, but with a wide range (1.5% - 5%) [BLS 1920]. These budget studies did not rely on regular survey data, frequently using estimates by the authors or placing a standard amount ($70) to fill in the gaps. In a later effort to construct category weights for a consumer price index in 1917-18, the Bureau of Labor Statistics surveyed 12,096 urban families and determined that average medical expenditures were $64, 4.7% of total consumption (BLS, 1924).
10. This growth rate for 1910-1930 based on Census measures of measures of persons with health occupations rather than employment per se.
11. See discussion of calculating growth rates and 1930 health share in Appendix A.
12. Williams (1932, page 291) states "The number of American trade union members who secure medical, surgical or hospital care as a benefit…is negligible." See also Rorem (1937), Reed (1940, 1966), Klem (1942).
13. The rate of increase in real per capita health spending 1930-1955 (3.7%) is slightly larger than for 1910-1930 (3.5%) even though the rate of excess medical cost growth is much lower (0.4% v. 1.4%) because per capita incomes grew so much more rapidly during the later period. See Appendix A for details.
14. *Research expenditures: see* Shyrock (1947c), Swain (1962), Harden (2015), Moses et. al. (2015).
15. Table 6. The American Hospital Association has tabulated data on the number, admissions, days of care, revenues, expenditures and FTE employee of hospitals annually since 1946, with the most recent data being available in the annual AHA Trendwatch Chartbook online at http://www.aha.org/research/reports/tw/chartbook/ The American Medical Association tabulated slightly different data for selected years from 1909 to 1953, so the estimates for years prior to 1946 are not exactly comparable. Most of the data is available in *Historical Statistics of the United States* (2006) in Tables Bd83-Bd-276, and the recent data is also available in *Health, United States* for various years. According to *The Lancet* Vol.2:pp 717-720, the cost of private hospital beds was $2 to $5 per day 1874.
16. Table 7. Provider percentages for 1960-2016 are from CMS (2017), for 1955 from Reed and Hanft (1966), for 1929 from CCMC(1932) and for 1910 Lough (1935). Categorizations for 1910 and 1929 prior to the development of NHEA are not fully comparable with recent data.
17. Table 8. Payer percentages for 1960-2015 are from CMS (2017) NHEA, for 1950 from Reed & Hanft (1966), and for 1929 from CCMC (1932). Coverage percentages for 2015 are from *Health United States, 2016*, from 1959-2007 from Cohen et. al. (2009), and for prior years from Numbers (1979).
18. See Reed (1947), Sinai, Anderson and Dollar (1947), Interim Report on Health Insurance (1960), Anderson (1990), Corning (1969), Scofea (1994), Cunningham & Cunnigham (1997), Thomasson (2002), Morrisey (2008).
19. CMS OACT NHE 2015 Table 5. Note that that the taxes supporting Medicare and worker's compensation are categorized as being sponsored by business and households rather than government. In addition, the tax subsidy for private health insurance is about $300 Billion, 9% of total national health expenditures (CBO 2016).
20. Figure 5 data is from Table A4: sources are Census for population, BLS for GDP and deflator, and OACT for NHE. Note that the percentage rate of growth in NHE is less than the height of the stacked bars in years such as 1974 or 2009 where GDP growth is negative, or 1997 and 2013 where due to lagging response the "excess" growth rate is negative.
21. Appendix A for discussion of version changes in the NHEA and other differences in data sources.
22. See Appendix B. GDP is smoothed with a 6-year moving average or real per capita GDP and a 3-year moving average of the inflation deflator; see Getzen (199, 2000b, 2014a, 2016a) and Smith et. al. (1998).
23. Roehrig et al. (2012, 2014), White & Ginsburg (2012), Mellman (2012), Levitt et.al. (2013), Ryu et. al. (2013) Blumenthal, Stremikis, Sahni (2013), Cutler & Sahni (2013), Chernew (2014), DiMaggio (2016).

24. Although Table 12 labels the span from 1880 to 1910 as a late pre-scientific era, a case could readily be made for considering those years as part of the early transition. The classification here is based on the limited data available for the 19th century that indicate little or no growth in the health share of GDP before 1890, and that most physicians, nurses and pharmacists were practicing alone with limited expertise (Shryock 1947, 1960; Anderson 1990; Duffy 1993; Warner 2014). Another consideration is that contemporary accounts attest that the major centers of medical research and training were still located in Europe, and that insurance plans, already well established in England, Germany, Sweden, France and elsewhere, were still essentially absent from the U.S. (Rubinow 1913, Williams 1932). Within the next two decades the situation changed substantially. Nascent Blue Cross plans provided a homegrown voluntary United States health care financing plan that was used to support real medical schools and research centers. Arguing that the 20th century U.S. health transition really got underway much before 1900, or that it was not already well underway by 1920, is a difficult stretch.
25. From 1930 to 1955 real per capita health spending more than doubled from $298 to $691, or 3.4% per year. Real per capita GDP income also more than doubled, from $7,854 to $16,593 or 3.0% per year, so that excess growth increased the health share of GDP by just 0.4% annually over this twenty-five year period. Field (2003, 2011) provides detailed evidence regarding the technological vitality and productivity of the U.S. economy post-depression. 1910 -1955 could be considered a single forty-five year formative era rather than being split at 1929 or 1930 – and which year is chosen makes a difference. If the split is made at 1930 the early & mid transition annualized growth rates are calculated to be 1.4% & 0.4% rather than 1.0% & 0.7%. 1929 is such a break in trend that a single year makes a major difference in estimated rates of growth over multiple decades.
26. Reimbursement formulas and regulations used by federal and state plans have slowly been making voluntary private mechanisms more outdated and less central to the health care system as doctor bills or hospital chargemasters became more and more divorced from actual costs and less and less accurate reflections of actual transactions (Reinhardt 2006; Kennedy 2011; Baker, Bundrof, Royalty 2013; Bai & Anderson 2016; Batty and Ippolito 2017). Randomized clinical trials, evidence-based medicine and clinical algorithms have become more important in medical practice. However, these changes in payment and quality control have been implemented gradually over decades and do not show any obvious breakpoint during the 1990s that would explain a shift that cut the rate of excess cost growth in half.
27. Table 10. Tracking the distribution of health expenditures across age groups over time is complicated by inconsistencies in measurement, particularly regarding the inclusion of institutional long-term care and home health. Therefor Table 10 relies most heavily on two sources that use consistent methods to cover extended spans of time, Meara, White and Cutler (2004) for 1963-2000, and CMS (2017) NHE Age and Gender Tables for 2002-2012. All of the other sources have been reviewed and a spreadsheet including data from all sources for all available years can be obtained from the author. The 1953 estimate from Cutler and Meara (1997) is based on the NORC survey conducted by Odin Anderson (1956) and therefore differs somewhat from later estimates, but was included here so as to provide a better sense of spending patterns for the decades prior to the development of Medicare and expansion of insurance coverage. Other sources consulted include Cooper, Wothington and McGee (1973), Fisher (1980), Waldo et. al. (1985, 1989); Keehan et. al. (2004); Hartman et al. (2009); and Lassman et. al. (2014).
28. Table 11. Note that the last column of Table 10, percentage of spending age 65+, applies to personal health spending. In order to decompose NHE, the 15% not directly attributable to individual patients (research, administration, overhead, construction, public health) must be allocated proportionately (as is done here) or by some other method.
29. The 65+ group accounted for 20% of expenditures in 1963 and 43% in 1987 as the health share of GDP increased from 5.4% to 10.6%. Hence it is not unreasonable to extrapolate that of the +5.2% incremental increase in the health share of GDP, +3.4% (about 2/3^{rds}) could be attributed to the elderly, rising from 1.1% of GDP (20% of 5.4%) to 4.5% (43% of 10.6%).
30. The CBO projection methodology is explained in the annual Long Term Budget Outlook (CBO 2017) posted on the CBO website. The CMS has posted a projection methodology paper (CMS 2017a) and provides it most recent publication on the CMS NHE website and in a Health Affairs article (Keehan et.

al. 2017). The SOA projection methodology is described in a technical manual posted along with the most recent model update on the SOA website (SOA 2017).

31. Keehan et. al. (2017) projects the health share of GDP to be 19.9% of GDP in 2025. An assessment of the accuracy of CMS 10-year projections over the last two decades by Getzen (2016b) indicates cumulative error and drift of approximately ±1% per year (±10% per decade). Estimates of uncertainty in forecasts for more than a decade are problematic. Silver (2015) describes weather forecasters as using massive models that have become quite good for making forecasts up to 10 days into the future, but for any forecast longer than that must default to very simple historical averages (and to make climate change projections over centuries or millennia must use entirely different kinds of models). Analogously, inertia and business cycle lags within the health care system allow for fairly good forecasts up to 10 years, but for anything longer must default to simple long-run historical averages---and raise the question of whether the average should be for the last twenty-, fifty-, or two-hundred years and if it should be weighted. The judgment made for the SOA model is that the twenty-five year average provides the best trade-off between currentness and length.
32. Family medical premiums in 2015 averaged $18,142 in 2016 (KFF 2016), and out-of-pocket costs would add about 10%, meaning that to be comfortably insured without subsidies would take more than 1/3 of the $55,000 median family income.
33. Regarding insurance coverage, see Cohen (2009), Health, United States, 2016 (2017). Business contribution 15% and falling see Table 05, "National Health Expenditures by Type of Sponsor," on the CMS 2016 NHE website. For the decline in defined benefit pensions, see Jaffe (2004), Butica et. al. (2009), McWhinney (2016).
34. Weil (2007) states "*The conclusion from the literature is that residual productivity is by far the most significant source of income differences [p.1267]"* and later adds "*analysis will also have to account for the different speeds at which health affects the economy through various channels. [p.1302]"* The measurement of growth due to technology as a residual is also discussed in Weisbrod (1991), Newhouse (1992), Smith, Heffler, and Freeland (2000), Cutler & McClellan (2001), Murphy &Topel (2003), Weil (2007), Smith, Newhouse, Freeland (2009), Corrado & Hulten (2010) and Chandra & Skinner (2012).
35. Martin Feldstein (2017) notes "change in the "real output" of any narrowly distinguished type of service is defined by the BEA by dividing the total expenditure on that service by an input price index (page 7)." … "The official GDP statistics for the health care industry focus on costs, ignoring the effect of the health products and services on the health of the patient (page 8). The lag between CPI increases and consumption expenditures is discussed in Appendix B, and can be viewed as a form of measurement error in construction of a deflator. Use of a "price index" for medical care is particularly problematic: see Langford (1957), Getzen (1992a), Boskin et al. (1997), Landefeld and Parker (1997), Berndt (2001), Mackie & Schultz (2002), Lebow and Rudd (2003), Schreyer (2012), Coyle (2014) Manski (2015), Hult, Jaffe, Philipson (2016).
36. Much of the decline in mortality is attributable to medical science, but not to clinical practices per se. See Cutler & Miller (2005), Cutler, Deaton & Lleras-Muney (2006).
37. Hillman & Schwartz (1985), Trajtenberg (1990), Mokyr (1998), Geljijns & Rosenberg (1994), Gelijns, Zivin & Nelson (2001), Cutler & McClellan (2001a), Bud (2007). Willeme & Dumont (2015).
38. David (1990), Blume (1992), Schlich (2002), North (2005), Comin, Hobijn, Rovito (2006), Mina et al (2007), Consoli & Mina (2009), Nabel & Braunwald (2012), Jones (2017).
39. McKinlay (1981), Weisbrod (1991), Newhouse (1992), Peden & Freeland (1998), Schlich (2002), McClellan & Cutler (2001a), Smith, Newhouse & Freeland (2009).
40. Voluntary institutions, see Goldman (1948), Shryock (1960), Somers & Somers (1961), Relman (1980), Ginzberg (1984), Kronick (2001), Jacobson (2001), Hammer (2001), Gruber & Rodriguez (2007), Brubaker (2017).
41. Price transparency, chargemasters & pospective payment: see Bai & Anderson (2016), Xu, Park, Bai (2017), Batty & Ippolito (2017), and Clemens & Gottlieb (2017).
42. As hospitals became "health systems" leveraged with millions of dollars in debt financing they inevitably acted like more like corporations than local charities even if they retained the not-for-profit tax status (Needleman 2001; Lindrooth & Weisbrod 2007). A recent contrary example is provide by the billion dollar home nursing corporation Bayada, still controlled by its original owner, Mark Baiada, who

is now trying to make the firm into a linked series of local non-profit entities in order to preserve its charitable purpose.

43. See Anders & McGinley (1996), Getzen & Schoenthal (2005). Perry & Stone (2011), Waldman (2011), Roebuck (2016). The Getzen (2013) health economics textbook terms this process "Financial Reimbursement Cycles" (pp: 229-231).
44. Senate Subcommittee on Primary Health and Aging (2014); Hulse (2016), Dave, et. al. (2017).
45. Clemens & Ippolito (2017). With real per capita incomes growing at 2% per year, a health share of GDP at 4% and excess medical cost growth rate of +1.5% per year, then the percentage of marginal income growth consumed by medical care is (.015+.02)*.04)/(.02) =7%. The share of income growth consumed by medical care rises to 26% =(.015+.02)*.15)/(.02) when the health share of GDP is 15%. In 2025, assuming the pessimistic expectations of just 1% annual real per capita income growth expressed by Gordon (2016) are born out and the health share of GDP exceeds 20%, the medicine could consume more than half of all incremental income growth each year, ((.015+.01)*.20)/(.01) =70%.
46. From 1900 to 1940, 34 of the 42 Nobel Prizes in Medicine came from Europe and just 4 from the USA, the first of which was in awarded in 1933. Since 1940, the majority of the prizes have been award to scientists from the USA.
47. OECD Health Data 2016 and previous years; Gerdtham et. al . (1992); Gerdtham and Jönsson (2000). Horenstein and Santos (2017). Note that OECD health expenditures data for the USA differs slightly from the CMS OACT NHE estimates. See also White (2007), Garber & Skinner (2008), NAP (2013).

Notes to Appendices A and B

48. IRS records and other sources are used to estimate the numbers who are self-employed or in partnerships.
49. Developing a total for "medical care" using occupations requires a judgment call as to which should be included, and the nomenclature and classification of occupations varies over time.
50. see note 35 on real output and use of GDP deflators.
51. BEA nominal GDP, although frequently revised, is the generally accepted standard for measurement of national income. Errors in population estimates have no effect on estimated share, and trend variation from year to year is small enough to be disregarded when measuring changes in per capita expenditures. However, use of deflators to create real expenditure series is problematic. New products, quality change and the inability to consistently define meaningful units of quantity for many services, including medical care, make inflation adjustment increasingly questionable over time or across countries. That is one reason that shares rather than real per capita expenditures are preferred when estimating trends over more than five years or making international comparisons.
52. Seale (1959) appears to have been the first to report lags in national health expenditures and Getzen (1985) the first estimates of lag coefficients. Complexity, information asymmetry, contractual incompleteness, institutional ossification, and moral entanglements may all play a role in making the health sector slow to respond (Arrow 1963; Frandsen, Brigham, Rebitzer 2017). The fact that most consumption is less volatile than income and tends to respond with a lag that displaces and dampens business cycles has long been noted (Cochrane 2016; Ramey 2016). In his Nobel Address Deaton (2016) noted his early research showing how unexpected changes in inflation create delays in the consumer purchasing response (Deaton 1977). Some of the challenges in determining temporal dynamics are addressed by Sims (1974, 1980, 1996), Cochrane (1994), White & Granger (2011) Ramey (2016), and Muller & Watson (2017).
53. In principle, adjustment to a major shock might take any of three rather different shapes: a sharp and immediate rise or fall, a linear shift that spans an extended period, or a curvilinear "bell-shaped normal growth curve" that starts slow, rises exponentially and gradually fades. The econometrics of determining the shape of response is challenging since the magnitude and propagation of shocks may vary substantially with each occurrence

#######

REFERENCES

Abel-Smith, Brian (1963). *Paying for Health Services*. Geneva: World Health Organization.

Abel-Smith, Brian (1965). The Major Pattern of Financing and Organisation of Medical Services That Have Emerged in Other Countries. *Medical Care* 3(1):33-40.

Abel-Smith, Brian (1967). *An International Study of Health Expenditure*. Geneva: World Health Organization.

Abraham, Katherine G., and Christopher Mackie. 2005. *Beyond the Market: Designing Nonmarket Accounts for the United States*. Washington, DC: National Academies Press.

Acemoglu (2012) *Why Nations Fail: The origins of power, prosperity and poverty.* New York: Crown.

Ackerknecht Erwin H. (1982) *A short history of medicine.* Baltimore: Johns Hopkins U Press.

Aizcorbe, Ana M. (2013). Recent Research on Disease-Based Price Indexes: Where Do We Stand? *Survey of Current Business* 93(July):9-13.

Aizcorbe, Ana M. and Nicole Nestoriak. (2008). Toward a Health Care Satellite Account. *Survey of Current Business* 88(May):24-30.

American Hospital Association (1971) *Budgeting Procedures for Hospitals*. Chicago: American Hospital Association.

Anders, George and Laurie McGinley, (1996) "How Do You Tame a Wild U.S. Program? Slowly and Reluctantly. Medicare Home Health Visits Are a Boon for Entrepreneurs; Costs Explode 30% a Year," *Wall Street Journal*, 6 March 1996, sec. A, p. 1ff

Anderson, Odin W (1956) *Family Medical Care Expenditures and Voluntary Health Insurance: A Nationwide Survey*. New York: The Blackstone Division.

Anderson, Odin W (1963) *Changes in Family Medical Care Expenditures and Voluntary Health Insurance: A Five-Year Resurvey*. Cambridge: Harvard U Press.

Anderson, Odin W (1990) *Health services as a growth enterprise in the United States since 1875*. Ann Arbor, Mich: Health Administration Press.

Arrow, Kenneth J. (1963). Uncertainty and the Welfare Economics of Medical Care. *American Economic Review* 53(5):141-149.

Bai, Ge and Gerald Anderson. (2016) U.S. Hospitals Are Still Using Chargemaster Markups to Maximize Revenues. *Health Affairs* 35(9):1658-1664.

Baker, Laurence, MK Budorf, Anne Royalty. (2013). Private Insurers' Payments for Routine Physician Office Visits Vary Substantially Across the United States. *Health Affairs* 32(9):1583-1590.

Barer, M., et al. 1989. "Trends in the Use of Medical Services by the Elderly in British Columbia." *Canadian Medical Association Journal* 141 (1): 39-45.

Barer, M.L., R.G. Evans, and C. Hertzman. 1995. "Avalanche or Glacier? Health Care and the Demographic Rhetoric." *Canadian Journal on Aging* 14(2): 193-224.

Batty, Michael and Benedic Ippoito. (2017)Mystery of the Chargemaster: Explaining the Role of Hospital List Prices in What Patients Actually Pay. *Health Affairs* 36(4):689-696.

Beck, Andrew J. (2004) The Flexner Report and the Standardization of American Medical Education. *JAMA* 05 May 2004 Vol. 291(17).

Becker, Gary S. Tomas J. Philipson and Rodrigo R. Soares. (20015). The Quantity and Quality of Life and the Evolution of World Inequality. *American Economic Review* 95(1):277-291.

Bernard, Didem, et al. (2012) Reconciling Medical Expenditure Estimates from the MEPS and NHEA, 2007. *Medicare & Medicaid Research Review*, 2(4):E1-E20.
https://www.cms.gov/mmrr/Downloads/MMRR2012_002_04_a09.pdf

Berndt, E. R. 2001. "Price Indexes for Medical Care Goods and Services: An Overview of Measurement Issues." In *Medical Care Output and Productivity*, edited by D. M. Cutler and E. R. Berndt, pp. 141–98. Chicago, IL: University of Chicago Press.

Bisin, Alberto and Thierry Verdier. (2017). On the Joint Evolution of Culture and Institutions. NBER wp#23375.

BLS (1920) U.S. Bureau of Labor Statistics *Standards of Living: A compilation of budgetary studies*. Bureau of Applied Economics.

BLS (1924) U.S. Bureau of Labor Statistics (BLS), *Cost of Living in the United States, 1917–19*, Bulletin number 357 (May 1924).
Blume, Stuart (1992) *Insight and industry: on the dynamics of technological change in medicine*. MIT Press, Boston
Blumenthal, David, Kristof Stremikis, David Cutler. (2013) Health Care Spending—A Giant Slain or Sleeping? *New England Journal of Medicine* 396(26):2551-2557.
Bordley, James. (1976) Two centuries of American medicine, 1776-1976. Philadelphia: Saunders.
Boskin, Michael, Ellen R. Dulberger, Robert J. Gordon, Zvi Griliches, and Dale W. Jorgenson. 1997. "The CPI Commission: Findings and Recommendations." *American Economic Review* 87(2):78–83.
Boustan, Leah P. Devin Bunten Owen Herey. (2013). Urbanization in the US 1800-2000 NBER wp#19041.
Bradley, R., E. Cardenas, D. H. Ginsburg, L. Rozental, and F. Velez. (2010). "Producing Disease-Based Price Indexes." Monthly Labor Review 133 (2): 20–8.
Bradley, Ralph. 2013. "Feasible Methods to Estimate Disease Based Price Indexes." *Journal of Health Economics* 32(3): 504–514.
Brubaker, Harold. (2017) Bayada Home Health Transfer to Nonprofit Will Start Next Spring. Philadelphia Inquirer. August 17, 2017.
Bryan, Leon S. (1964). Blood-letting in American Medicine, 1830-1892. *Bulletin of the History of Medicine* 38:516-29.
Bud, Robert (2007). *Penicillin: Triumph and Tragedy*. New York: Oxford.
Butrica Barbara A. et. al. (2009). The Disappearing Defined Benefit Pension and Its Potential Impact on the Retirement Income of Baby Boomers. Social Security Bulletin 69(3):
Bynum, William F. (1994). *Science and the Practice of Medicine in the Nineteenth Century*. Cambridge: Cambridge U Press.
Case, Anne and Angus Deaton (2015). Rising morbidity and mortality in midlife among white non-Hispanic Americans in the 21st century, *PNAS* 112(49) Dec 8, 2015.
Case, Anne and Angus Deaton (2017). *Mortality and Morbidity in the 21st Century.* Brookings Papers on Economic Activity. March 17, 2017.
Catlin Aaron C. and Cathy A. Cowan. (2015) History of Health Spending in the United States, 1960-2013. https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/Downloads/HistoricalNHEPaper.pdf
CBO. (2016) *Private Health Insurance Premiums and Federal Policy*. Washington DC: USGPO.
CBO. (2017). *The 2017 Long Term Budget Outlook*. Washington DC: Congressional Budget Office; https://www.cbo.gov/publication/52480
CCMC. (1932) *Medicine and Society in America: Final Report of the CCMC*. U Chicago (Arno Press 1972).
Chandra Amitabh, & Jonathan Holmes, & Jonathan Skinner,(2013). *Is This Time Different? The Slowdown in Healthcare Spending,* NBER wp#19700 and Brookings Papers on Economic Activity, vol. 47(2 (Fall)), pages 261-323.
Chandra, Amitabh and Jonathan Skinner, (2012) Technology Growth and Expenditure Growth in Health Care. *Journal of Economic Literature*, 50(3):645-680.
Chen, Alice, Dana Goldman. (2016). Health Care Spending: Historical Trends and New Directions. *Annual Review of Economics* 8(1):291-316. NBER 2015.
Chernew, Michael (2014) Examining the Present and Future of the Health Spending Growth Slowdown. *Health Affairs Blog*, 03 September 2014: http://healthaffairs.org/blog/2014/09/03/examining-the-present-and-future-of-the-health-spending-growth-slowdown/.
Chernew, Michael and Joseph Newhouse, (2012), Health Care Spending Growth., Handbook of Health Economics, Chapter 1 pgs 1-43. *Handbook of Health Econo*mics. [electronic resource]. Vol. 2 edited by Mark V. Pauly, Thomas G. McGuire, Pedro P. Barros.
Chernichovsky, Dov and Sara Markowitz. (2004). "Aging and Aggregate Costs of Medical Care: Conceptual and Policy Issues." *Health Economics* 13 (6):543-562.
Clemens Jeffrey & Joshua D. Gottlieb, (2017). "In the Shadow of a Giant: Medicare's Influence on Private Physician Payments," *Journal of Political Economy*, vol. 125(1), pages 1-39.
Clemens, Jeffrey and Bendic Ippolito (2017) Uncompensated care and the Collapse of Hospital Payment Regulation: An Illustration of the Tingbergen Rule. *NBER* w23758

CMS (2009). U.S. Department of Health and Human Services, Centers for Medicare & Medicaid Services, Office of the Actuary. *Summary of National Health Expenditure Account 2009 Comprehensive Revisions*. Available at https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-andReports/NationalHealthExpendData/Downloads/benchmark2009.pdf

CMS (2010) 2010 Comprehensive Revision. https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/Downloads/2010ComprehensiveRevision.pdf

CMS (2015) *National Health Expenditure Accounts: Methodology Paper, 2015: Definitions, Sources and Methods*. https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/Downloads/DSM-15.pdf

CMS (2017a) *Projections of National Health Expenditures: Methodology and Model Specification.* 2/15/2017. https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/Downloads/ProjectionsMethodology.pdf

CMS (2017b) *NHE Age and Gender Tables*; accessed 15 July 2017 at https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/Age-and-Gender.html

Cochrane, John H. (1994) Shocks. *Carnegie-Rochester Conference Series on Public Policy* 4:295-364.

Cohen, Robin et al. (2009) *Health Insurance Coverage Trends, 1959-2007*. USDHHS, DCD, NCHS National Health Statistics Reports #17, July 1, 2009.

Comin, Diego A., Bart Hobijn, Emilie Rovito (2006) World Technology Usage Lags. NBER wp#12677.

Consoli, Davide and Andrea Mina. (2009) An evolutionary perspective on health innovation systems. J *Economic Evolution* 19:297-319.

Cooper, Barbara, Nancy L. Worthington, and Mary F. McGee. (1973) *Compendium of national health expenditures data*. Social Security Administration, Office of Research and Statistics, USDHEW, Pub. No. (SSA)73-11903, Washington DC: USGPO.

Cooper, Zack, Amada Kowalski, Eleanor Powell, Jennifer Wu (2017) Politics, Hospital Behavior, and Healthcare Spending. *NBER* wp#23748

Corning, Peter A. (1969) The Evolution of Medicare. Social Security Administration: https://www.ssa.gov/history/corning.html

Corrado, Carol A. and Charles R. Hulten. (2010) How Do You Measure a "technological Revolution?" American Economic Review 100(May):99-104.

Costa, Dora. 2015. Health and the Economy in the United States from 1750 to the Present. JEL 53(3):503-570

Coyle, Diane. (2014). GDP, a brief but affectionate history. Princeton: Princeton U Press.

Cunningham 1997 Robert C, III and Robert M. (1997) *The Blues : a history of the Blue Cross and Blue Shield System*: DeKalb: Northern Illinois U Press.

Cutler David, Allison B Rosen, Sandeep Vijan (2006). The value of medical spending in the United States, 1960–2000. *New England Journal of Medicine*. 355:920–27

Cutler David, Angus Deaton, Adriana Lleras-Muney. (2006). The Determinants of Mortality*. Journal of Economic Perspectives*, 20 :3, 97-120.

Cutler, David and Fiona Scott Morton (2013) Hospitals, Market Share, and Consolidation. *JAMA* 310(18):1964-1970

Cutler, David and Mark McClellan (2001a). Productivity Change in Health Care. *American Economic Review* 91(May):281-286.

Cutler, David and Mark McClellan. (2001b). "Is Technological Change in Medicine Worth It?" *Health Affairs* 20 (5): 11–29.

Cutler, David and Nikhil Sahni (2013). If Slow Rate of Health Care Spending Growth Persists, Projections May be off by $770 Billion. *Health Affairs* 32(5):

Cutler, David M. and Grant Miller. 2005. "The Role of Public Health Improvements in Health Advances: The Twentieth-Century United States." *Demography.* February, 42:1, pp. 1–22.

Dave, Chintan V. et. al. (2017) High Generic Drug Prices and Market Competition*. Annals of Internal Medicine*, 167(3):145-151.

David, Paul A. (1990) The Dynamo and the Computer: An Historical Perspective on the Modern Productivity Paradox. *American Economic Review* 80(2):355-361.

Davis, Michael (1941) *America Organizes Medicine*. New York: Harper.

Deaton, Angus. (2016) Measuring and Understanding Behavior, Welfare, and Poverty (Nobel Lecture). *American Economic Review* 106(6):1221-1243.
Deaton, Angus. 1977. "Involuntary Saving through Unanticipated Inflation." *American Economic Review* 67 (5): 899–910.
Denison, Edward F. and Alvin Slater (1943) Incomes in Selected Professions: Part 4, Medical Service. *Survey of Current Business*, Oct 1943, p. 16-20.
Diamond, Dan. (2017) *How Hospitals Got Richer Off Obamacare*. Politico: HTTP://www.politico.com/healthcare.
Dickinson Frank G. and J. Raymond (1955) The Economic Position of Medical Care 1929-1953. *JAMA* 159(1):41-50 159(2):119-127.
DiMaggio (2016) Health Spending Slowed Down in Spite of the Crisis. Federal Reserve Bank of New York Staff Reports, no. 781. https://www.newyorkfed.org/research/staff_reports/sr781.html
Dodd, Don. (1993). *Historical statistics of the states of the US: two centuries of the census, 1790-1990.* Westport, Conn: Greenwood Press.
Donahoe, Gerald F. (2000). CAPITAL IN THE NATIONAL HEALTH ACCOUNTS. https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/Downloads/capital.pdf
Dranove (2009) *The Economic Evolution of American Health Care*. Princeton
Dublin, Louis I. (1927). What Price Doctors? *Harper's Magazine*, Nov 1, 1917, pp. 767-776.
Duffy, John.(1993) *From Humors to Medical Science: A History of American Medicine* Chicago: U Chicago Press.
Dunn, Abe, L. Rittmueller, and Bryn Whitmire. (2015). *Introducing the New BEA Health Care Satellite Account*. Bureau of Economic Analysis January 2015. https://www.bea.gov/scb/pdf/2015/01%20January/0115_bea_health_care_satellite_account.pdf
Dunn, Abe, Scott Grosse, Samuel Zuvekas. (2016) Adjusting Health Expenditures for Inflation: A Review of Measures for Health Services Research in the United States. *HSR: Health Services Research Online* November 21, 2016:1-22 .
Dzau, Victor J. et. al. J (2010) The role of academic health science systems in the transformation of medicine *The Lancet* 375:949-953.
EBRI (2002*) History of Health Insurance Benefits*. Washington DC: Downloaded from EBRI.org. July 2017.
Edwards, Alba M. (1943*) Comparative Occupational Statistics for the United States, 1870 to 1940*, Bureau of the Census, Washington DC: USGPO.
Falk I.S., M.C. Klem and N. Sinai. 1933. *The Incidence of Illness and the Receipt and Costs of Medical Care among Representative Family Groups*. Committee on the Costs of Medical Care Publication #26, Chicago: University of Chicago Press.
Falk, Isidore (1936) *Security against sickness; a study of health insurance*. Garden City NY: Doubleday.
Feldstein, Martin. (2017) Underestimating the Real Growth of GDP, Personal Income, and Productivity *Journal of Economic Perspectives* 31(2):145-164.
Fernald John G. & Charles I. Jones. (2014). "The Future of US Economic Growth," American Economic Review, American Economic Association, vol. 104(5), pages 44-49.
Fetter Bruce (2006). Origins and Elaboration of the National Health Accounts, 1926-2006. *Health Care Financing Review* 28(1):53-67.
Field, Alexander. (2003). The Most Technologically Progressive Decade of the Century. *American Economic Review* 93:1399-1411
Field, Alexander. (2011). *Great Leap Forward: 1930s Depression and U.S. Economic Growth*. New Haven: Yale U Press.
Flexner, Abraham. (1910) *Medical Education in the United States and Canada.* New York: Carnegie Foundation, http://archive.carnegiefoundation.org/pdfs/elibrary/Carnegie_Flexner_Report.pdf
Fogel, Robert W. (2004) *The Escape from Hunger and Premature Death, 1700-2100*. Cambridge: U Press.
Fogel, Robert W. et. al. (2013) *Political Arithmetic: Simon Kuznets and the empirical tradition in Economics.* Chicago: U Chicago Press.
Foster, Ann C. (2010) Out-of-Pocket health care expenditures: a comparison. Monthly Labor Review. (February):3-19.
Foster, Ann C. (2016*) Household healthcare spending: comparing the Consumer Expenditure Survey and the National Health Expenditure Accounts, 2011-2014*. https://www.bls.gov/cex/nhe_compare_201114.pdf

Frandsen, Brigham, Powell M., Rebitzer JB. (2017) Sticking Points: Common-Agency Problems and Contracting in the U.S. Healthcare Systems. NBER working paper #23177.
Fuchs, Victor H. (1974) *Who Shall Live? Health, Economics and Social Choice*. New York: Basic books.
Fuchs, Victor. (1979) Economics, Health and Post-Industrial Society. *Milbank Memorial Fund Quarterly* 57(2):153-182.
Galor, Oded (2011) *Unified Growth Theory.* Princeton: Princeton U Press.
Galor, Oded and David N. Weil. (2000). Population, Technology, and Growth: From Malthusian Stagnation to the Demographic Transition and Beyond. *American Economic Review*, 90, no.4, 806-828.
GAO (1976) History of the Rising Costs of Medicare and Medicaid and Attempts to Control These Costs 1966-1975.
Garbarino. JW. 1959 Price Behavior and Productivity in the Medical Market. *Monthly Labor Review* 13(1):3-15.
Garber, Alan, and Jonathan Skinner. (2008) Is American Health Care Uniquely Inefficient? *Journal of Economic Perspectives* 22(4): 27-50.
Gelijns A.C., Zivin J,Nelson RR. (2001) Uncertainty and technological change in medicine. *Journal of Health Politics, Policy & Law* 26:913–924
Gelijns AC, Rosenberg N (1994) The dynamics of technological change in medicine. *Health Affairs13*(3):28–46
Gerdtham, U., J. Sogaard, F. Andersson, and B. Jonsson. (1992). "An Econometric Analysis of Health Care Expenditure: A Cross-section Study of the OECD Countries." *Journal of Health Economics* 11 (1): 63-84.
Gerdtham, Ulf-G. und Bengt Jönsson (2000) International Comparisons of Health Expenditure: Theory, Data and Econometric Analysis, in Tony Culyer and Joe Newhouse (eds.) *Handbook of Health Economics* , Amsterdam: Elsevier Science, 12-53
Getzen, Thomas E. (1985). Reducing Healthcare Costs. *Journal of Healthcare Financial Management*, 39(3):34-38.
Getzen, Thomas E. (1990). Macro Forecasting of National Health Expenditures." pp: 27-48 in L. Rossiter and R. Scheffler, eds. *Advances in Health Economics*, Vol. 11, JAI Press: Greenwood, CN.
Getzen, Thomas E. (1992a). Population Aging and the Growth of Health Expenditures." *Journal of Gerontology: Social Sciences* 47(3):S98-104.
Getzen, Thomas E. (1992b). Medical Care Price Indexes: theory, construction and empirical analysis of the U.S. Series 1927-1990." *Advances in Health Economics* (L Rossiter & R Scheffler, eds.), Volume 13:85-128.
Getzen, Thomas E. (1994). U.S. Health Services Employment: A Time Series Analysis" with Michael Kendix, *Health Economics* 3(3):169-181.
Getzen, Thomas E. (2000a). Health care is an individual necessity and a national luxury: applying multilevel decision models to the analysis of health care expenditures. *Journal of Health Economics* 19(2):259-270.
Getzen, Thomas E. (2000b). "Forecasting Health Expenditures: Short, Medium and Long (long) Term." *Journal of Health Care Finance* 26 (3): 56-72.
Getzen, Thomas E. (2006). Aggregation and the Measurement of Health Care Costs." *HSR: Health Services Research 41*(5):1938-1954, October 2006.
Getzen, Thomas E. (2013). *Health Economics & Financing, 5th edition.* New York: J. Wiley & Sons.
Getzen, Thomas E. (2014a). Macroeconomic Dynamics of Health: Lags and Variability in Mortality, Employment and Spending," in Anthony J. Culyer, (ed) *Encyclopedia of Health Economics*, v.2: 165-176. San Diego: Elsevier; 2014.
Getzen, Thomas E. (2014b). Modeling the Cost of Medical Care for the Elderly. *SOA Healthwatch*, January 2014 74:21-25.
Getzen, Thomas E. (2016a). Measuring and Forecasting Global Health Expenditures," Chapter 3, Volume 1 in *Global Handbook of Health Economics*, ed. R Scheffler. World Scientific: London. 2016.
Getzen, Thomas E. (2016b). Accuracy and Range of Actuarial Projections of Health Care Costs. *North American Actuarial Journal,* 20(2):101-113
Getzen, Thomas E. and Anna R. Schoenthal (2005). Bariatric Surgery and the Financial Reimbursement Cycle. *Journal of Health Care Finance*. 31(3):1-9.

Ginzburg, Eli. (1984). The Monetarization of Medical Care. *New England Journal of Medicine* 310(18): 1162-1165.
Glied, Sherry, Stephanie Ma and Claudia Solis-Roman. (2016) Where The Money Goes: Evolving Expenses Of The US Health Care System *Health Affairs* 35(7):1197-1203.
Goldmann, Franz. (1948) *Voluntary Medical Care in the United States.* New York: Columbia University Press.
Gordon, Robert J. (2016) *The Rise and Fall of American Growth: The U.S. Standard of Living since the Civil War*. Princeton: Princeton U press.
GPIH – Global Price and Income History Group. (2017) Occupation codes and counts, circa 1774. http://gpih.ucdavis.edu
Gruber, Jonathan and David Rodriguez. (2007) How Much Uncompensated care do doctors provide? *Journal of Health Economics* 26:1151-1169.
Haber, Susan G. and Joseph P. Newhouse. (1991). Recent revisions to and recommendations for national health expenditures accounting. *Health Care Financing Review* 13(1):111-116.
Hall, Robert E, Charles I Jones. (2007). The Value of Life and the Rise in Health Spending. *Quarterly Journal of Economics* 122 :1, 39-72.
Hammer, 2001). Arrow's Analysis of Social Institutions: Entering the Marketplace with Giving Hands? Journal of Health Politics, Policy and Law 26(5):1165-.
Harden (2015) A Short History of the NIH http://history.nih.gov/exhibits/history/index.html
Harris, Seymour E. (1964). *The Economics of American Medicin*e. New York: Macmillan.
Hartman, Micah B., Robert J. Kornfeld, and Aaron C. Catlin. (2010). A Reconciliation of Health Care Expenditures in the National Health Expenditures Accounts and in Gross Domestic Product. *Survey of Current Business*. 90(9):42-52.
Health Care Financing Review CFR. (2005) Key Milestones in Medicare and Medicaid History: 1965-2003. *Health Care Financing Review*. 27(2):1-3.
Health, United States, 2016. (2017) DHHS Pub No. 2017-1232. https://www.cdc.gov/nchs/data/hus/hus16.pdf
Hertzler Arthur E. (1938). *The Horse and Buggy Doctor*. New York: Harper.
Hiles, David R. H. (1992) Health services: the real jobs machine. *Monthly Labor Review*, November: 3–16.
Hillman AL, Schwartz JS (1985) The adoption and diffusion of CT and MRI in the United States: a comparative analysis. *Medical Care* 23(11):1283–1294
Horenstein AR, Santos MS. (2016). Understanding Growth Patterns in US Health Care Expenditures. SSRN#2942535.
Horowitz, Jill R. and Austin Nichols. (2009) Hospital ownership and medical services: Market mix, spillover effects, and nonprofit objectives. *Journal of Health Economics*. 28:924-937.
HSUS (1975) *Historical Statistics of the United States, Colonial Times to 1970*. Bureau of the Census, U.S. Dept. of Commerce. Washington DC: USGPO.
HSUS (2006) *Historical Statistics of the United States, Millennial Edition*. ed. Susan B. Carter et al. New York: Cambridge U Press.
Hulse, Carl (2016) Congress Presses Pharmaceutical Company to Explain Surge in Cost of EpiPen. New York Times Aug 23. http://nyti.ms/2bwA8Xi.
Hult, Christopher, Sonia Jaffee, Tomas Philipson (2016). How Does Technological Change Affect Quality-Adjusted Prices in Health Care? NBER wp#22986
Illich, Ivan (1976) Medical Nemesis: The Expropriation of Health. New York: Pantheon.
Illinois Bureau of Statistics. (1884). Six Families Budget Their Money, 1884. *Illinois Bureau of Statistics, Third Biennial Report*, (Springfield, Ill.: 1884).
Interim report on health insurance, U.S. National Health Survey. United States, July–Dec 1959. Series B, No. 26. Washington, DC: U.S. Department of Health, Education, and Welfare, Public Health Service. 1960. 36.
Jacobson, Peter D. (2001) Regulating Health Care: From Self-Regulation to Self-Regulation? Journal of Health Politics, Policy and Law 26(5):1081-.
Jaffe, Jim. (2004) The Decline of Private-Sector Defined Benefit Promises and Annuity Payments: What will it mean? EBRI Notes 25(7):2-8.
Jones, David S. (2017) CABG at 50 (or 70?) *New England Journal of Medicine* 376(19):1809-1811.

Kahl, Ann and Donald Clark (1986) Employment in Health Services: LT trends and projections. *Monthly Labor Review*. Aug 1986, 17-36
Kaiser Family Foundation. (2013). Assessing the Effects of the Economy on the Recent Slowdown in Health Spending. April 22. http://tinyurl.com/lo3sgh3 (also listed as Leavit et. al, 2013)
Keehan, Sean P. et. al. (2017) National Health Expenditure Projections, 2016-20125: Price Increases, Aging, Push Sector to 20 Percent of Economy. *Health Affairs* 36(3):1-11.
Kennedy, Kelly. (2011). Health care costs vary widely, study shows. *USA Today*, 30 June 2011. Accessed at http://www.usatoday.com/money/industries/health/2011-06-30-health-costs-wide-differences-locally_n.htm
Kett, Joseph F. (1968). *The Formation of the American Medical Profession: The Role of Institutions, 1780 - 1860.* New Haven: Yale U press.
KFF (2010) Family Health Premiums Rise 3 Percent to $13,770 in 2010, But Workers' Share Jumps 14 Percent as Firms Shift Cost Burden. Kaiser Family Foundation, www.kff.org, Sept 02, 2010.
KFF (2016) *2016 Employer Health Benefits Survey*. http://www.kff.org/health-costs/report/2016-employer-health-benefits-survey/
King, Lester S. (1991) *Transformations in American Medicine: From Benjamin Rush to William Osler.* Baltimore: Johns Hopkins U Press.
Klarman, H.E. (1977). The Financing of Health Care. *Daedalus* 106(1):215-234.
Klarman, Herbert E. (1979). Health Economics and Health Economics Research. Pages 81-89 in Daniel M. Fox (1979) *Economists and Health Care*. New York: Prodist.
Kleiner, Morris M. (2016) Battling over Jobs: Occupational Licensure in Health. *American Economic Review* 106(5):165-170..
Klem, Margaret C. (1942) Some Recent Developments in Voluntary Health Insurance. *Social Security Bulletin* (August):5-16
Kronick, Richard. (2001). Valuing Charity. *Journal of Health Politics, Policy and Law*. 26(5):993-1001.
Kuznets, Simon (1937) *National Income and Capital Formation, 1919-1935, a preliminary report*. New York: National Bureau of Economic Research.
Kuznets, Simon (1971) *Economic Growth of Nations; total output and production structure*. Cambridge, Mass: Belknap.
Landefeld, J. S., and R. P. Parker. (1997). BEA's Chain Indexes, Time Series, and Measures of Long-Term Economic Growth. *Survey of Current Business* 77 (5): 58–68.
Langford, Elizabeth A. (1957). Medical Care in the consumer Price Index, 1936-56. *Monthly Labor Review* (9):1053-1058.
Lazenby, Helen C. et. al. (1992). National Health Accounts: Lessons from the US Experience. *Health Care Financing Review* 13(4):89-103.
Lebergott, Stanley. (1964). *Mapower in economic growth; the American record since 1800*. New York: McGraw-Hill.
Lebergott, Stanley. (1996). *Consumer Expenditures: New measures and old motives*. Princeton: Princeton U Press.
Lebow, David E. and Jeremy B. Rudd (2003) Measurement Error in the Consumer Price Index: Where do we stand? *Journal of Economic Literature* 41(March):159-201.
Lee, Ronald. (2003) The Demographic Transition: Three Centuries of Fundamental Change. *Journal of Economic Perspectives* 17(4):167-190.
Levit, Katharine R. et. al. (1994). National Health Expenditures, 1993. *Health Care Financing Review* 16(1):247-294.
Levitt, Larry, et. al. (2013) Assessing the Effects of the Economy on the Recent Slowdown in Health Spending. Kaiser Family Foundation April 22, 2013. http://www.kff.org/health-costs/issue-brief/assessing-the-effects-of-the-economy-on-the-recent-slowdown-in-health-spending-2/ also http://tinyurl.com/lo3sgh3.
Lindert, Peter H. and Jeffrey G. Williamson (2016) *Unequal Gains: American Growth and Inequality since 1700*. Princeton U Press.
Lindrooth, Richard C. and Burton A. Weisbrod. (2007) Do religious nonprofit and for-profit organizations respond differently to financial incentives? The hospice industry. *Journal of Health Economics*. 26:342-357.
Lister, Joseph. 1867. "On the Antiseptic Principle in the Practice of Surgery." *Lancet,* 90 (2299): 353-356.

Lough, William H. (1935) *High-level consumption, its behavior; its consequences.* New York: McGraw-Hill.
Machlin, S.R., Valluzi, J.L., Chevarly, M., et al.: Measuring Ambulatory Health Care Use in the United States: A Comparison of 1996 Estimates Across Four Federal Surveys. *Journal of Economic and Social Measurement* 27(1-2):57-69, 2001.
Mackie, C., and C. L. Schultze (eds.).(2002). *At What Price? Conceptualizing and Measuring Cost-of-Living and Price Indexes.* Washington, DC: National Academies Press.
Makuc, Diane M. et. al. (2009). *Health Insurance Coverage Trends, 1959-2007*. National Health Statistics Reports, N.17, July 1, 2009.Washington DC: CDC NCHS.
Manski, Charles F. (2015) Communicating Uncertainty in Official Economic Statistics*. Journal of Economic Literature.* 53(3):631-653.
Marks (1997) *The Progress of Experiment: Science and Therapeutic Reform in the US 1900-1990*. Cambridge: Cambridge U Press.
Marmor, Theodore. (2000). The Politics of Medicare. New York: Aldine de Gruyter.
Mays, Rick (2007) Origins Development, and Passage of Medicare's revolutionary Prospective Payment System. *Journal of the History of Medicine and Allied Sciences* 62(1):21- 55.
McKeown, Thomas. (1976) *The Modern Rise of Population*. New York: Academic Press.
McKinlay John B. (1981) From 'promising report' to 'standard procedure': seven stages in the career of a medical innovation. *Milbank Memorial Fund Quarterly* 59(3):374–411.
McWhinney, James E. (2016) Demise of the Defined-Benefit Pan. Ivestopeida. http://www.investopedia.com/articles/retirement/06/demiseofdbplan.asp
Meara, Ellen, Chapin White, and David M. Cutler, (2004), Trends in Medical Spending by Age, 1963–2000. *Health Affairs* 23(4):176–183.
Millard, Candice. (2011) *The destiny of the republic : a tale of madness, medicine, and the murder of a president.* New York: Doubleday.
Mina A, Ramlogan R, Tampubolon G, Metcalfe JS (2007) Mapping evolutionary trajectories: applications to the growth and transformation of medical knowledge. *Research Policy* 36(5):789–806
Mokyr, Joel (2011). *The Gifts of Athena*. Princeton: Princeton U Press.
Mokyr, Joel and Rebecca Stein (1997). Science Health and Household Tech: The Effect of the Pasteur Revolution on consumer Demand. Page:143-206 in Timothy F. Bresnahan and Robert J. Gordon, eds., *The Economics of New Goods*. Chicago: NBER and U Chicago Press.
Mokyr, Joel. (1998) Induced Technical Innovation and Medical History. *Journal of Evolutionary Economics*. 8:119-137.
Morgan, David and Roberto Astolfi. (2013). *Health Spending Growth at Zero: Which countries, which sectors are most affected?* OECD Health Working Papers No. 60. Paris: OECD.
Moro, Alessio, Solmaz Moslehi, Satoshi Tanaka. (2017) Does Home Production Drive Structural Transformation? *American Economic Journal: Macroeconomics* 9(3)116-146.
Morrisey, Michael A. (2008) *Health Insurance*. Chicago: Health Administration Press.
Moses, Hamilton et. al. (2013) Anatomy of Health Care in the US *JAMA, The Journal of the American Medical Association* 310(Nov):1947-1963
Moses, Hamilton et. al. (2015) The Anatomy of Medical Research: US and International Comparisons*. JAMA* 313(2):174-189.
Mount Vernon (2017) Death of George Washington. *Digital Encyclopedia of George Washington*. Accessed 29 August 2017. http://www.mountvernon.org/george-washington/death
Muller, Ulrich and Mark W. Watson. (2017). Long-Run Covariability. NBER wp#23186.
Murphy, Kevin M., and Robert H. Topel. (2006)The Value of Health and Longevity. *Journal of Political Economy*, 114(5):871-904.
Murphy, Kevin M., and Robert H. Topel. (2003*) Measuring the Gains from Medical Research: An Economic Approach.* Chicago:NBER and University of Chicago Press.
Murray, John E. (2007) *Origins of American Health Insurance*. New Haven: Yale U Press.
Nabel, Elizabeth G .and Eugene Braunwald. (2012) A Tale of Coronary Artery Disease and Myocardial Infarction. *New England Journal of Medicine*. 366(10:54-63.
NAP (2005) *Beyond the Market Designing Nonmarket Accounts for the US.* Washington DC: National Academies Press.

NAP (2013) *US Health in International Perspective: Shorter Lives, Poorer Health*, ed Steven H. Wolf and Laudan Aron. Washington DC: NAP Pres.
NAP (2016) *Families Caring for an Aging America*. Washington DC: National Academies Press.
Needleman, Jack 2001 The Role of Nonprofits in Health Care. *Journal of Health Politics, Policy and Law* 26(5)):1113-.
Newhouse, Joseph P. (1977). Medical Care Expenditure: A Cross-national Survey. *Journal of Human Resources* 12 (1): 115-125.
Newhouse, Joseph. (1992). Medical Care Costs: How Much Welfare Loss? *Journal of Economic Perspectives*. 6(3):3-21.
Nordhaus, William D. (2002) The Health of Nations: Contribution of Improved Health to Living Standards. NBER working Paper #8818.
North, Douglass C. (1990) *Institutions, institutional change, and economic performance*. Cambridge: Cambridge U Press.
North, Douglass C. (2005) *Understanding the Process of Economic Change*. Princeton: Princeton U Press.
Numbers, Ronald L. The Third Party: health Insurance in America in Vogel & Rosenberg (1979) and also in Leavitt, Judith W. and Ronald L. Numbers *Sickness and Health in America: An Overview*. Madison: U Wisconsin Press, 1978.
OECD (2017) *OECD Health Data 2016*. http://www.oecd.org/els/health-systems/health-statistics.htm
Osler, William 1922 *The evolution of modern medicine; a series of lectures delivered at Yale university* April 1913. New Haven: The Silliman Foundation.
Osler, William (1892, 1909, 1984) *The Principles and Practice of Medicine*. Norwalk, Conn.: Appleton-Century-Crofts.
Osler, William (1919) *A concise history of Medicine*. Baltimore: Medical Standard Book Co.
Paulson, George (2006) Death of a President and his Assassin—Error in their Diagnosis and Autopsies. *Journal of the History of the Neurosciences*. 2:77-91.
Peden, E. Freeland, M., 1998. Insurance Effects on U.S. Medical Spending (1960-1993). Health Economics 7, 671-87.
Perkins Barbara P. (1998). Economic Organization of Medicine and the Committee on the Costs of Medical Care. *American Journal of Public Health* 88(11):1721-1726.
Perry, JE and RC Stone (2011). In the Business of Dying: Questioning the Commercialization of Hospice. *Journal of Law, Medicine and Ethics*, (Summer):224-234.
Porter, Roy. (1998). *The Greatest Benefit to Mankind: A Medical History of Mankind*. New York: WW Norton.
Ramey, Valerie (2016). Macroeconomic Shocks and their Propagation. NBER wp#21978.
Reed and Ruth Hanft (1966). National health Expenditures, 1950-64. *Social Security Bulletin* 29(1):3-19.
Reed, Louis S. (1940) Costs and Benefits Under Prepayment Medical Service Plans. *Social Security Bulletin* 3(3):13-26.
Reed, Louis S. (1966) Private Health Insurance: Coverage and Financial Experience, 1940-1966. *Social Security Bulletin*. 29(11):3-22.
Reed, Louis S. and Dorothy P. Rice (1964). National Health Expenditures: Object of Expenditures and Source of Funds, 1962. *Social security Bulletin* 27(8):11-21.
Reed, Louis S. *Blue Cross and Medical Service Plans.* Washington, D.C.: U.S. Public Health Service, 1947.
Reinhardt, Uwe (2003). Does the Aging of the Population Really Drive the Demand for Health Care? *Health Affairs* 22(11):627-639.
Reinhardt, Uwe. (2006). The Pricing of U.S. Hospital Services: Chaos Behind a Veil of Secrecy. *Health Affairs* 25(1):57-69.
Relman Arnold S. (1980) The Medical Industrial Complex. *New England Journal of Medicine* 303(17):963-970.
Rice, Dorothy P. and Barbara S. Cooper (1970). National Health Expenditures, 1929-68. *Social Security Bulletin*. 33(1):3-20.
Risse Guenther B, Ronald Numbers, JW Leavitt. (1977Medicine Without Doctors: Home Health Care in American History.) NY: Science History Publications.

Roebuck, Jeremy. (2016). Nurse Convicted in scheme to Bilk Medicare of $9 million. *Philadelphia Inquirer*, 09 February 2016.
Roehrig (2014). National health Spending in 2014—Acceleration Delayed. *New England Journal of Medicine* 371(19):1767-1769.
Roehrig, Charles et. al. (2012) When the Cost Curve Bent—Pre-Recession Moderation in Health Care Spending. *New England Journal of Medicine* 367(7):590-593.
Roehrig, Charles, George Miller, Craig Lake, and Jenny Bryant. (2009). National Health Spending by Medical Condition, 1996-2005. *Health Affairs* 28 March:w358-w367.
Rorem, Rufus (1937) *Hospital Care Insurance*. Chicago: American Hospital Association.
Rorem, Rufus (1982) *A Quest for Certainty: essays on health care economics, 1930-1970*. Ann Arbor, Mich: Health Administration Press.
Rosen, Allison B. et. al. (2017). Strengthening National Data to better measuring what we are buying in health care: Reconciling National Health Expenditures with Detailed Survey Data. NBER wp#23290.
Rosen, Allison B., and D. M. Cutler. (2009). "Challenges in Building Disease-Based National Health Accounts." *Medical Care* 47(7 Suppl 1): S7–13.
Rosen, George. (1944). *The Specialization of Medicine, with special reference to Ophthalmology*. New York: Arno.
Rosen, George and Charles E. Rosenberg (1983) *The Structure of American Medical Practice, 1875-1941* Philadelphia: U Penn Press.
Rosen, George. (1946) Fees and Fee Bills: Some Economic Aspects of Medical Practice. Baltimore: Johns Hopkins U Press.
Rosenberg, Charles E. (1987). *The Care of Strangers: the Rise of America's Hospital System*. New York: Basic Books.
Rosenberg, Charles E. 1968 *The trial of the assassin Guiteau; psychiatry and law in the gilded age*. U Chicago Press.
Rubinow, Isaac M. (1913) *Social Insurance*. New York: Henry Holt and Company (also dated 1916).
Rush, Benjamin. (1815) *Medical Inquiries and Observations*. Philadelphia.
Rutkow, Ira (2006). *James A. Garfield*. New York, New York: Macmillan.
Rutkow, Ira (2010) *Seeking the Cure: A History of Medicine in America*. New York: Scribner.
Ryu, Alexander et. al. (2013). The Slowdown in Health Care Spending 2009-2011. *Health Affairs* 32(5).
Schaffer, Amanda (July 25, 2006). A President Felled by an Assassin and 1880's Medical Care. *The New York Times*. New York, New York
Schlich T (2002) *Surgery, science and industry: a revolution in fracture care, 1950–1990s.* Hampshire: Palgrave MacMillan,
Schreyer, Paul (2012) Output, Outcome and Quality Adjustment in Measuring Health and Education Services. *Review of Income and Wealth*.58(2):257-278.
Scitovsky, Anne A. Changes in the Costs of Treatment of Selected Illnesses, 1951-65. *American Economic Review* 57(5):1182-1195.
Scofea, Laura A. (1994) Development and Growth of Employer-Provided Health Insurance. 1994. *Monthly Labor Review*. (March):3-10.
Seale, J.R. (1959) A General Theory of National Expenditure on Medical Care. *The Lancet*. 10 October 1959. 555-559.
Selden, (2001) T., Levit, K., Cohen, J., et al.: Reconciling Medical Expenditure Estimates from the MEPS and NHA, 1996. *Health Care Financing Review* 23(1):161-178.
Senate Subcommittee on Primary Health and Aging. (2014). *Why are some Generic Drugs Skyrocketing in Price?* https://www.help.senate.gov/hearings/why-are-some-generic-drugs-skyrocketing-in-priced.
Sensenig, Arthur L., and Ernest Wilcox. 2001. "National Health Accounts National Income and Product Accounts Reconciliation: Hospital Care and Physician Services." In *Medical Care Output and Productivity*, ed. David M. Cutler and Ernst R. Berndt, 271–302. Chicago: University of Chicago Press.
Shryock Richard H. (1947a) The American Physician in 1846 and 1946. *JAMA* 134(5):417-424.
Shryock Richard H. (1947b) *The Development of Modern Medicine*. New York: Knopf.
Shryock Richard H. (1947c) *American Medical Research: Past and Present*. New York: Commonwealth Fund.

Shryock Richard H. (1967). *Medical Licensing in America, 1650-1965.* Baltimore: Johns Hopkins U Press.
Shryock, Richard H. (1960). *Medicine and Society in America 1660-1860*. New York: New York U Press.
Silver, Nate. (2015) *The Signal and The Noise.* New York: Penguin.
Sims, Christopher (1974). Distributed Lags. In Intrilligator & Kennrick (eds.) *Frontiers of Quantitative Economics II*: Amsterdam: North Holland.
Sims, Christopher (1980). "Macroeconomics and Reality", *Econometrica*, January 1980, pp. 1-48.
Sims, Christopher (1986). "Macroeconomics and Methodology", *Journal of Economic Perspectives*, 10, Winter 1996, 105-120.
Sinai, Nathan (1931) *A survey of the medical facilities of the city of Philadelphia: 1929, being in part a digest of the "Philadelphia hospital and health survey, 1929*. (CCMC pub. No. 9) Chicago: University of Chicago Press.
Sinai Nathan, Odin W. Anderson, and Melvin L. Dollar (1946). *Health Insurance in the United States.* New York.
Sing M. et al. (2006) Reconciling Medical Expenditure Estimates from the MEPS and NHEA, 2002 *HCFA Review* 28(1):25-41
Smith Sheila D., Newhouse JP, Freeland M. (2009). Income, insurance, and technology: why does health spending outpace economic growth? *Health Affairs* 28(5): 1276–1284.
Smith, Sheila D. Stephen K. Heffler, and Mark S. Freeland, Ph.D. (2000) The impact of technological change on health care costs and spending: an evaluation of the literature. https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/Downloads/tech_2000_0810.pdf
Smith, Sheila D., et al (1998). "The Next Ten Years of Health Care Spending: What Does the Future hold?" *Health Affairs* 17 (5): 128-140.
SOA (2017) *Modeling Long Term Healthcare Cost Trends—Update for 2018.* Schaumberg IL: Society of Actuaries. https://www.soa.org/research-reports/2016/research-hlthcare-trends/
Sobek, Matthew (2001) New Statistics on the U.S. Labor Forces, 1850-1990. Historical Methods 34(2):71-87.
Somers, Herman M. and Anne R. Somers. (1961) *Doctors Patients, and Health Insurance*. Washington DC: Brookings.
Squires, David. (2014) "The Global Slowdown in Health Care Spending Growth." *Journal of the American Medical Association*, 312, no.5 (2014): 485-486. A
Starr, Paul. (1984, 2008) *Social Transformation of American Medicine: The rise of a sovereign profession and the making of a vast industry*. New York: Basic Books.
Stevens, Rosemary. (1971). *American Medicine and the Public Interest. New Haven:* Yale U Press.
Stevens, Rosemary. (1998). *In Sickness and in Wealth: American Hospitals in the Twentieth Century.* Baltimore: John Hopkins University Press.
Stigler, George J. (1954). The Early History of Empirical Studies of Consumer Behavior. *Journal of Political Economy.* 42(2):95-113.,
Stigler, George J. (1956) *Trends in Employment in the Service Industries*. Princeton: NBER and Princeton U Press.
Stone, Richard (1997) The Accounts of Society. *American Economic Review* 87(6):17-29.
Swain DC. (1962). NIH 1930 to 1950. *Science* (14 Dec 1962).
Thomasson, Melissa A. (2002) From Sickness to Health: The Twentieth-Century Development of U.S. Health Insurance. *Explorations in Economic History* 39:233-253.
Thomasson, Melissa A. and Jaret Treber (2008) From Home to Hospital: The Evolution of Childbirth in the United States, 1927-1940. *Explorations in Economic History* 45(1):76-99.
Thompson, John D. and Grace Goldin. *The Hospital: a social and architectural history.* New Haven: Yale U Press.
Thorpe KE, CS. Florence, DH Howard, P Joski. (2004) The Impact of Obesity on Rising Medical Spending. Health Tracking. W4-480–W4-486 *Health Affairs*
Tomes, Nancy 2016. *Remaking the American Patient.* U North Carolina Press.
Trajtenberg, Manuel. *Economic analysis of Product Innovation: The case of CT scanners*. (1990). Cambridge MA: Harvard U Press.

Turner, Ani and Paul Hughes-Cromwick (2013) Connecting US Health Expenditures with the Health Sector Workforce. Business Economics 48:42-57.
US Bureau of the Census (Edwards, Alba M). (1943) *Comparative Occupational Statistics for the United States, 1870 to 1940*. Washington DC: USGPO.
US Bureau of the Census (1949) *Historical statistics of the United States, 1789-1945: a supplement to the Statistical abstract of the United States*. (Continuation to 1952 with revisions of selected series, published 1954). Washinton, DC: USGPO.
Vanoli, Andre (2005). *A history of national accounting.* Washington, DC: IOS Press.
Vogel Morris, Rosenberg M. 1979. *The Therapeutic Revolution: Essays in the social history of American medicine.* Philadelphia: U Penn Press.
Vogel, Morris (1980) *The Invention of the Modern Hospital, Boston 1870-1930.* Chicago: U Chicago Press.
Waldman, Peter. (2011) Aided By Referral Bonuses, Hospice Industry Blooms. *The Washington Post/Bloomberg*, December 17, 2011.
Waldo Daniel R, Sonnefeld ST, McKusick DR, et al. (1989) Health Expenditures by Age Group, 1977 and 1987. *Health Care Financing Review*. Summer; 10(4):111–120
Wallenborn, White McKenzie. (1997) George Washington's Terminal Illness: A Modern Medical Analysis of the Last Illness and Death of George Washington. The Washington Papers University of Virginia. http://gwpapers.virginia.edu/history/articles/illness/
Warner, John Harley. (2014) *The Therapeutic Perspective: Medical Practice, Knowledge, and Identity in America, 1820-1885*. Princeton: Princeton U Press.
Washington, A. Eugene, Molly J. Coye, David Tl. Feinberg. (2013) Academic Medical Centers and the Evolution of the Health Care System. JAMA 310(18):1929-1930.
Weil, David N. (2007) Accounting for the Effect of Health on Economic Growth. *Quarterly Journal of Economics*. 1265-1306
Weinfeld, William "Income of Physicians, 1929-1949," *Survey of Current Business*, July 1951, p. 9-26.
Weisbrod, Burton A. (1991). The Health Care Quadrilemma: An Essay on Technological Change, Insurance, Quality of Care, and Cost Containment. *Journal of Economic Literature*, XXIX:523–552.
White, Chapin and Paul Ginsburg. (2012) Slower Growth in Medicare Spending—Is this the new normal? *New England Journal of Medicine*. March 7, 2012.
White, Chapin. (2007). Health Care Spending Growth: How Different is the United States from the Rest of the OECD?" *Health Affairs* 26(1):
White, Halbert and Clive WJ Granger. (2011) Consideration of Trends in Time Series. *Journal of Time Series Econometrics* 3(1):article 2.
Willeme P., Dumont M. (2015). Machines That Go 'PING': medical technology and health expenditures in OECD countries. *Health Economics*. 24:1027-1041.
Williams, Pierce. (1932) *The Purchase of Medical Care Through Fixed Periodic Payment*. NBER (downloaded from http://www.nber.org/books/will32-1 July 2017)
Williamson, Jeffrey G. (1967). "Consumer Behavior in the Nineteenth Century: Carroll D. Wright's Massachusetts Workers in 1875." *Explorations in Entrepreneurial History, Second Series*, 4 (2): 98–135.
Worboys, Michael. (2011). Practice and the Science of Medicine in the Nineteenth Century. *Isis* 102:109-115.
Wright, Carroll D. (1894) *Analysis and Index of All Reports Issued by Bureaus of Labor Statistics prior to November 1, 1892*. Washington DC: USGPO.
Wright, Carroll D. (1900) *History and Growth of the United States Census.* Washington DC: USGPO.
Xu, Tim, Angela Park, Ge Bai. Variation in Emergency Department vs Internal Medicine Excess Charges in the United States. JAMA Internal Medicine 177(8):1139-1145.
Zuvekas, Samuel H., and Gary L. Olin. (2009). Accuracy of Medicare Expenditures in the Medical Expenditure Panel Survey. *Inquiry* 46, no. 1 (Spring): 92–108.