

Roh, Chul-Young; Kim, Sangheon

Article

Medical innovation and social externality

Journal of Open Innovation: Technology, Market, and Complexity

Provided in Cooperation with:

Society of Open Innovation: Technology, Market, and Complexity
(SOItmC)

Suggested Citation: Roh, Chul-Young; Kim, Sangheon (2017) : Medical innovation and social externality, Journal of Open Innovation: Technology, Market, and Complexity, ISSN 2199-8531, Springer, Heidelberg, Vol. 3, Iss. 3, pp. 1-8,
<http://dx.doi.org/10.1186/s40852-017-0056-1>

This Version is available at:

<http://hdl.handle.net/10419/176542>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<https://creativecommons.org/licenses/by/4.0/>

RESEARCH

Open Access



Medical innovation and social externality

Chul-Young Roh^{1*} and SangHeon Kim²

* Correspondence:

chulyoung.roh@lehman.cuny.edu

¹Department of Health Sciences,
Lehman College/CUNY, 250 Bedford
Park Blvd West, Bronx, NY 11064,
USA

Full list of author information is
available at the end of the article

Abstract

Healthcare expenditure in the United States has grown and will continue to increase. The increasing healthcare expenditure is to reduce real income as well as to diminish total utility and increase financial stresses. This study argues that the most critical factor that increases healthcare expenditures during last 50 years has been the advent, adoption and diffusion of new medical technologies that include new drugs, equipment and healthcare delivery systems. This study introduces various examples how medical innovations influence to increase healthcare expenditures. In company with the advanced medical technology, this study suggests a free market in medical technology that means less regulation and less subsidization to healthcare market participants, such as healthcare providers, insurers, and healthcare consumers to reduce healthcare expenditures.

Keywords: Medical innovation, Healthcare expenditure, Social externality

Introduction: medical technologies

Healthcare expenditures in the United States have grown from \$27.4B (or 5.0% of the GDP) in 1960 to \$2.9 trillion (or 16.4% of the GDP) in 2013. Out of that amount in 2013, 53% was financed by private insurances and out-of-pocket payments from consumers, while 47% came from public health programs, such as Medicare, Medicaid and other federal or state healthcare programs (CBO, 2015). The Congressional Budget Office (CBO) estimates that national expenditures for healthcare will continue to increase to about one-quarter of GDP by 2040 (CBO, 2015).

Healthcare expenditures per capita in the United States have increased from \$125, or 5.6% of per capita income (\$2219), in 1960 to \$7826, or 18.8% of per capita income (\$41,706), in 2013 (CDC, 2015). The healthcare expenditure per person, as well as the healthcare expenditure portion of personal income, have grown and will continue to increase. The effect of such increasing healthcare expenditures is to reduce real income. Such income reductions diminish total utility and increase financial stresses, especially among low income groups. One in five American adults is struggling to pay his healthcare bills, and over 62% of all personal bankruptcies have a medical cause (Himmelstein et al., 2009). Many with coverage are found to be under-insured and to have a responsibility for thousands of dollars in out-of-pocket expenses. Even though others have private insurance, they lose it when they become too sick to work. 25% of companies withdraw healthcare insurance immediately when their employees suffer from illness. Another 25% do so within 1 year (Pereira 2003). The loss of income from illness is common, but can often be coupled with high healthcare bills. Consequently, the burden of healthcare expenditure is linked to widespread indebtedness.

In addition to the growth of personal income and to changes in healthcare insurance coverage (which has declined as consumers have had to pay a greater share of medical expenses out-of-pocket), the most critical factor that has influenced the rise of per capita healthcare expenditures during the past 50 years has been the advent, adoption, and diffusion of new clinical technologies and healthcare services (CBO, 2008). Such advanced healthcare technologies allow healthcare professionals to diagnose and treat patients in methods that were never previously possible. Many of these healthcare innovations are accompanied with expensive new drugs, equipment, and skills. Other innovations are relatively inexpensive, but the cost of healthcare innovation has increased quickly as growing numbers of healthcare professionals and patients have used them. Even though technical advances in healthcare should reduce expenditures, instead, they have increased total healthcare spending.

Technologic innovations in HealthCare

Medical innovations have made significant contributions to improve the healthcare community, especially to expand patient longevity over the past 60 years, while healthcare expenditures have grown much faster than the overall economy. Medical innovations can consist of new medical and surgical procedures, such as joint replacement and angioplasty, equipment such as MRI and implantable defibrillators, and processes such as electronical medical records and transmission of information, and healthcare delivery via telemedicine. But innovations in healthcare delivery in the USA have not taken place and are not needed if the full benefits of innovation are accomplished from diagnostics, therapeutics, and devices (Aspden, 2002). The US health delivery system has been fragmented, and has not developed to accommodate the complexities of healthcare. There has been not enough investment and development in healthcare information systems. It is critical for the government to lead the development of innovations in healthcare delivery systems. Another characteristic of medical innovation is that medical devices and drugs have a different paradigms in innovation. Innovations in medical devices have a significant cost-effective improvement over time rather than innovations in drugs. For instance, innovations in implantable cardioverter defibrillators (ICDs) reduced the average cost of a life-year saved from about \$50,000 in the mid-1990 to nearly \$30,000 currently (Owens et al. 1997; Sanders et al., 2005; Weiss et al., 2002 and Hsu et al. 2002). Early cost-effectiveness studies for ICDs should be to present worst-case scenarios and could lead to premature abandonment.

Chandra and Skinner (2012) categorized three types of medical innovations based on average cost-effectiveness: (1) highly cost effective medical innovation where usage has a positive externality; (2) medical innovation that is clearly positive for a certain subset of patients, but that is seriously heterogeneous across populations; and (3) one that has poor cost-effectiveness for the overall majority of the patient population.

Innovation in healthcare can reduce expenditure in some instances. Certain types of preventative healthcare, for example, some vaccines, should decrease the chance of patient hospitalization for acute care, but examples of medical innovation that have proven long-term savings are few. Incremental innovation to design and production of healthcare devices can lower costs per unit. Such innovations aim to improve efficiency through lower-cost and higher quality of products and to develop the design and use of the device. This kind of innovation is possible from the contribution of developed

digital processing and computing capacity to cure patients and give healthcare a web-based platform and wireless technologies. These innovations may lead to improved productivity because of a reduced unit cost of procedure. On the other hand, these productive innovations cause an increase in demand for these procedures, drugs, and devices, and then serve to increase overall healthcare expenditure.

This type of medical innovation is cost-effective and useful for the relevant population. Improved health behaviors are included in this type of medical innovation (Cutler and Kadiyala, 2003). Antibiotics such as sulphonamide drugs made a contribution to reduce mortality rates in the early 20th century (Cutler et al., 2006). The advent of these drugs had extirpated pneumonia, tuberculosis, dysentery, and venereal disease. The development of low-cost antibiotic drugs made remarkable improvements in outcomes following outbreaks of bacterial meningitis (Chandra and Skinner, 2012). Surfactants that treat neonatal acute respiratory distress for newborn babies are highly cost-effective. These drugs were estimated to reduce the possibility of mortality by 30% and proved to be protective of costs that declined by 10% for survivors and 30% for the deceased (Schwartz et al., 1994).

However, these types of medical innovations are not always cost effective. The example is anti-retroviral drugs for HIV treatment to prevent the development of full-blown AIDS. Romley and his colleagues analyzed the life expectancy gains of people infected with HIV between the introduction of cART in 1996 and the 2009 guideline revisions. They concluded the patients who initiated treatment early could expect to live 6.1 years longer, and the earliest initiators could have an extra 9.0 years of life. Total value of life expectancy was \$80 billion, with each life-year valued at \$150,000 from those treatments (Romley et al, 2014). Another example of successful medical innovation is lung cancer treatment. Ramsey and his colleagues evaluated the economic impact of new lung cancer treatments alongside Southwest Oncology group Trial S9509. They estimated the cost-effectiveness of cisplatin plus vinorelbine versus carboplatin plus paclitaxel for patients with advanced non-small-cell lung cancer. They concluded that treatment with cisplatin plus vinorelbine is more cost-effective than treatment with carboplatin plus paclitaxel (Ramsey et al., 2002). Unfortunately, AIDS and lung cancer treatment cases are the exception rather than the norm.

The second type of medical innovation is one which is cost-effective for some patients but of declining marginal benefit for others. Many healthcare innovations relate to ongoing treatment for the management of chronic conditions such as diabetes and coronary artery disease. These types of healthcare innovations should increase costs in many ways (CBO, 2008; Newhouse, 1992). Innovative drugs and procedures that improve clinical outcomes and heal patients can change healthcare delivery systems and critical factors to raise healthcare costs. These healthcare innovations save and extend the lives of patients. They are critically important to patients as well as to society. For instance, by the middle of 1960s, the treatment for patients who suffered from coronary artery disease was not expensive, since caregivers did not do much to help patients. The standard treatment for patients with a heart attack was bed rest and morphine. Since then, major innovations in medical technology have made available a series of treatments. Many medical developments that decrease mortality rate and increase longevity of life increase healthcare spending, since surviving patients extend their lives and therefore consume healthcare services for more years.

Coronary angioplasty, developed in the 1970s, is a procedure used to widen blocked or narrowed coronary arteries (the main blood vessels supplying the heart). This surgery uses a balloon to stretch open a narrowed or blocked artery. However, most modern angioplasty procedures also involve inserting a short wire-mesh tube, called a stent, into the artery during the procedure. The stent is left in place permanently to allow blood to flow more freely. Coronary angioplasty can save cost per procedure for patients at first, but its advent actually increases total healthcare costs. Although this procedure provides the clinical benefits without the risk of open-heart bypass surgery, recurrence of artery blockage after angioplasty occurs frequently. It leads to many repeat procedures, and some failed angioplasties were followed eventually by bypass surgery. Total spending for heart disease patients increased after angioplasty was introduced (Cutler and Huckman 2003). Certain types of medical innovation entail fewer risks. For example, laparoscopy, a surgical procedure in which a fiber-optic instrument is inserted through the abdominal wall to view the organs in the abdomen or to permit a surgical procedure, increases costs not because each procedure is expensive, but because so many more patients may use this procedure. Even though healthcare costs per patient decrease, total costs to society as a whole increase (Cutler and Huckman, 2003).

The third type of medical innovation is treatment with considerable uncertainty of value or poor cost effectiveness. The classical example is arthroscopic surgery for osteoarthritis of the knee, a surgical procedure that can diagnose and treat problems in the knee joint. Kirkley and their colleagues conducted a single-center, randomized, controlled trial of arthroscopic surgery in patients with moderate-to-severe osteoarthritis of the knee. Patients were randomly assigned to surgical lavage and arthroscopic débridement together with optimized physical and medical therapy or to treatment with physical and medical therapy alone. They found that arthroscopic surgery for osteoarthritis of the knee does provide any additional benefit to optimized physical and medical therapy (Kirkley et al., 2008). Barnato et al (2007) examined whether variations across regions in end-of-life (EOL) treatment intensity are related with regional differences in patient preferences for EOL care. They concluded that Medicare beneficiaries preferred a focus on palliative care rather than life-extension care such as ICU for the chronically ill, which increases healthcare costs. Temel et al. (2010) argued that lung cancer patients who were treated with the advanced medical technology experienced worse quality of life and shorter life expectancy as compared with palliative care.

These types of innovations occur in common in health care, and lead to improvements due to reduced healthcare costs per procedure as well as to increased healthcare costs due to increased demand for these procedures. Even though medical innovations make an improvement, healthcare outcomes that change healthcare delivery can be a major contributor to rising healthcare costs. Medical innovations are valuable to patients and society, but they generally come with a significant additional healthcare costs.

Healthcare costs and technologic innovation

Most studies argue that medical innovation is the leading driver for rising healthcare expenditure (Wu and Shen 2014, Sorenson et al., 2013, Newhouse, 1992, Funchs and Sox 2001, Chernew et al., 1998, Baker et al., 2003). According to Newhouse (1992), medical innovation explains half of the increase in healthcare expenditure in the U.S.

over the last half century. For example, television, computers, automobiles, and cell phone, scientific innovations always raise expenditures, even these lower prices (Aaron, 2002). The price of laparoscopic cholecystectomy may be 25% less than one of open cholecystectomy, but the number of both types of cholecystectomy has increased by 60% (Legorreta et al, 1993). The growth of healthcare services increases the impact of price per unit. The direction of causality between medical innovation and healthcare expenditure is obvious. Baker et al. (2003) explored the relationship between new medical technologies and healthcare spending and utilization. The study focused on diagnostic imaging, cardiac treatment, cancer, and newborn care technologies. The researchers found that greater availability of medical technology is related to greater per capita use and higher spending on healthcare services. For example, although the increased demand of angioplasty should reduce the number of coronary bypass surgeries, the increased availability of angioplasty is related to more bypass surgery per population among elderly people over 65. Similarly, more magnetic resonance imaging (MRI) does not reduce the use of computed tomography (CT) scans performed.

Hay (2003) and Wu and Shen (2014) explored the factors that increase hospital inpatient expenditure. They found that with overall levels of economic activity, price-level variation, healthcare labor cost, and hospital market structure, technology that hospitals use is the critical cost driver in inpatient expenditures. According to the CBO report (2008), the procedure for bone marrow transplantation (also called as stem cell transplant) was used in treating a relatively small number of patients with aplastic anemia as well as some patients with leukemia in the late 1960s. Medical innovations in bone marrow transplantation have scaled up the group of patients who suffer from multiple myeloma, lymphoma, sickle cell disease, and other conditions. One major medical innovation in the 1990s was the advent of autologous transplantation that uses the patient's own stem cells. This medical innovation has greatly expanded the set of patients who need this type of therapy. Another example is joint replacement. Joint replacement surgery was introduced in the 1960. The innovated metals and plastics of today are stronger, longer-lasting, and less subject to corrosion than earlier models, and produce better long-term outcomes. Surgery for hip replacement performed in the U.S has been increasing and has become more common in younger patients. Over a 10 year period earlier in the decade, the number of hip replacements increased from 138,700 in 2000 to 310,800 in 2010. The number of hip replacements has increased by more than double in those aged 45 to 54 to 51,900 (Wolford et al., 2015).

Medical innovation has commanded a higher price per unit of healthcare services in the United States compared with other countries (Reinhardt et al., 2002). For example, greater intensive care use in the U.S. was most notable with elderly people; among patients over age 85 in the U.S., intensive care was used prior to 31.5% of medical deaths and 61.0% of surgical deaths, versus 1.9 and 8.5% of deaths, respectively, in the United Kingdom (Wunsch et al., 2009). This does not indicate that the United Kingdom refers too few patients to intensive care or the United States too many. Coupled with the cost-ineffectiveness of intensive care unit (ICU) days, the increase in ICU days in the U.S. is consistent with overall poor productivity in U.S. healthcare expenditures. The U.S. had almost three times more cardiac surgery units and catheterization laboratories than Canada, Germany, and other OECD countries. In 1997, the number of coronary

artery bypass surgeries and revascularization per capita was twice as high in the U.S. compared with 15 other OECD countries (Reinhardt et al. 2002).

The U.S. tends to easily accept expensive pharmaceutical treatments that have uncertain benefits. For example, Ezetimibe, an expensive drug to reduce plasma cholesterol levels, was recommended as a first-line treatment, and it was proved to be relatively ineffective at lowering cardiovascular disease. Jackevivius and her colleagues found that after adjusting for purchasing-power parity, expenditures for Ezetimibe, per 100,000 population, were higher in the U.S. than in Canada by a factor of more than 4 (Jackevivius et al. 2008). The per capita expenditures for ezetimibe were \$47 in the U.S. and \$2.16 in Canada, while the corresponding expenditure for statins were \$56.91 in the U.S. and \$50.31 in Canada.

Although innovations in medicine reduce the cost of producing health outcomes of any given level of quality, medical innovations in quality and rapid use of those technologies lead to higher total expenditure on healthcare services. Medical innovations may increase spending by the provision of a greater amount of healthcare services than would have been provided otherwise.

Implications for controlling rising healthcare costs

There is consensus that advanced medical technology is a major driver of increasing healthcare expenditures. Medical technology broadly includes medical equipment, devices, medicines, procedures, and new medical knowledge. According to the Kaiser Family Foundation, medical technologic innovation made a contribution to at least half of the growth in healthcare expenditures in the U.S. (Kaiser Family Foundation, 2007). The benefits from advanced medical technologies are to increase life expectancy, to reduce disability among patients, and to decrease the mortality from critical diseases like heart attacks, brain cancer, and kidney failure, but the many new expensive medical technologies make it imperative that those medical technologies are commonly used.

In order to assess the effectiveness of medical technologies, a well-coordinated, independent and evidence-based authority needs to be established. Although the Office of Technology Assessment (OTA) that was created in 1972 was intended to provide objective and authoritative evaluation of the complicated technical and scientific issues to Congress, the OIA was closed in 1995. At the moment, there is no nationally centralized organization to analyze the costs and clinical benefits of new medical technologies. The effectiveness of technologic evaluation is conducted by various private and public organizations such as the Agency for Healthcare Research and Quality (AHRQ), the Medicare Coverage Advisory Committee, and the Department of Veterans Affairs. Professional organizations, such as the American College of Cardiology, the American Heart Association, and the American Academy of Obstetrics and Gynecology, evaluate and decide the clinical effectiveness of the best practices. Payers, such as insurance companies and managed care companies, also determine their own criteria for any available assessments. Finally, healthcare providers and patients can decide the utilization of healthcare technology regardless of the effectiveness or costs of medical technology. The authorities that assess the clinical and economical costs as well as benefits of medical technology are uncoordinated and dispersed throughout the private and public sectors. To provide effective analysis of medical technology, authorities

have to be independent, have to evaluate the evidence-based assessment, and have to be well-coordinated.

A free market in medical technology would mean having less regulation. It would also mean less regulation and less subsidization to market participants, such as healthcare providers, insurers, and healthcare consumers. Its results would increase competition among healthcare providers and insurers, would provide more choices for healthcare consumers, and would lower healthcare expenditures. For example, the price for LASIK surgery has decreased to as low as \$200 per eye in some areas, dropping from as high as \$4000 per eye a few years ago. Government policies induce price and service competition among service providers to mitigate increasing healthcare expenditures.

To control healthcare expenditures from overuse of medical technologies, assessment of medical technology must be enhanced. The definition of assessment is to examine safety, efficacy, outcome and cost, usually performed to inform coverage or benefit design decisions (Mendelson, et al., 1995). The international Network of Agencies for Health Technology Assessment suggests health technology assessment be used to identify evidence on the costs and benefits of healthcare intervention, to synthesize health research findings about the effectiveness of the different interventions, to appraise the economic implications and analyze cost-effectiveness of intervention, and to evaluate social and ethical implications of the diffusion and use of medical technologies as well as the organizational implications (INAHTA, 2016). Useful and reliable information regarding medical technologies must be widely disseminated to the public to reduce the demand of medical technology from healthcare providers and consumers. After AHRQ was established, it has become the most prominent federal agency to authorize various types of research on the effectiveness of medical technologies in the U.S. An independent and nonpartisan agency, wholly free from political pressure, must be created to analyze clinical and cost-effectiveness of new medical technologies.

Author details

¹Department of Health Sciences, Lehman College/CUNY, 250 Bedford Park Blvd West, Bronx, NY 11064, USA. ²Graduate School of Public Administration, Seoul National University, 56-1 Sillim-dong, Gwanak-gu, Seoul, South Korea.

Received: 31 December 2016 Accepted: 31 January 2017

Published online: 16 February 2017

References

- Aaron, H. (2002). The Unsurprising Surprise of Renewed health care Cost Inflation. *Health Affairs*. doi:10.1377/hlthaff.w2.85.
- Aspden, P. (2002). *Medical Innovation in the Changing Healthcare Marketplace: Conference Summary*. Washington, DC: National Academic Press.
- Baker, K., Birnbaum, H., Geppert, J., Mishol, D., Moynour, E., (2003). The relationship between technology availability and health care spending. *Health Affairs*. W3-537-551. doi:10.1377/hlthaff.w3.537.
- Barnato, A., Herndon, M., Anthony, D., Gallagher, P., Skinner, J., Bynum, J., & Fisher, E. (2007). Are Regional Variations in End-of-Life Care Intensity Explained by Patient Preferences?: A Study of the US Medicare Population. *Medical Care*, 45(5), 386–393.
- Center for Disease Control and prevention (2015). National Center for Health Statistics. Health, United States, 2014: In Brief. http://www.cdc.gov/nchs/data/abus/abus14_inbrief.pdf. Accessed 3 Oct 2016.
- Chandra, A., & Skinner, J. (2012). Technology Growth and Expenditure Growth in Health Care. *Journal of Economic Literature*, 50(3), 645–680.
- Chernew, M., Hirth, R., Sonnad, S., Ermann, R., & Fendrick, A. (1998). Managed care, medical technology, and health care cost growth: a review of the evidence. *Medical Care Research and Review*, 55(3), 259–288.
- Congressional Budget Office (2008). Technological Change and the Growth of Health Care Spending. <https://www.cbo.gov/publication/41665>. Accessed 30 Sept 2016.
- Congressional Budget Office (2015). The Long-Term Outlook for Major Federal Health care Programs. <http://www.cbo.gov/sites/default/files/114th-congress-2015-2016/reports/50250/50250-breakout-Chapter2-2.pdf>. Accessed 30 Sept 2016.
- Cutler, D., & Huckman, R. (2003). Technological development and medical productivity: the diffusion of angioplasty in New York State. *Journal of Health Economics*, 22(2), 187–217.
- Cutler, D., & Kadiyala, S. (2003). The Return to Biomedical Research: Treatment and Behavioral Effects. In K. Murphy & R. Topel (Eds.), *Measuring the Gains from Medical Research: An Economic Approach* (pp. 110–162). Chicago: The University of Chicago Press.

- Cutler, D., Angus Deaton, A., & Lleras-Muney, A. (2006). The Determinants of Mortality. *Journal of Economic Perspectives*, 20(3), 97–120.
- Funchs, V., & Sox, H. (2001). Physicians' Views of the Relative Importance of Thirty Medical Innovations. *Health Affairs*, 20(5), 30–42.
- Hay, J. (2003). Hospital Cost Drivers: An Evaluation of 1998–2001 State-Level Data. *American Journal of Managed Care*, 9, S13–S24.
- Himmelstein, D., Throne, D., Warren, E., & Woolhandler, S. (2009). Medical Bankruptcy in the United States, 2007: Results of a National Study. *The American Journal of Medicine*, 122(8), 741–746.
- Hsu, J., Uratsu, C., Truman, A., Quesenberry, C., McDonald, K., Hlatky, M., & Selby, J. (2002). Life after a ventricular arrhythmia. *American Heart Journal*, 144(3), 404–412.
- International Network of Agencies for Health Technology Assessment (2016). HTA Network Multiannual Work Programme 2016–2020, http://ec.europa.eu/health/technology_assessment/docs/2016_2020_pgmnetwork_en.pdf. Accessed 18 Sept 2016.
- Jackevivius, C., Tu, J., Ross, J., Ko, D., & Krumholz, H. (2008). Use of Ezetimibe in the United States and Canada. *New England Journal of Medicine*, 358(17), 1819–1828.
- Kaiser Family Foundation (2007). Snapshots: How Changes in Medical Technology Affect Health Care Costs. <http://kff.org/health-costs/issue-brief/snapshots-how-changes-in-medical-technology-affect/>. Accessed 15 Sept 2016.
- Kirkley, A., Birmingham, T., Litchfield, R., Giffin, J., Willits, K., Wong, C., Feagan, B., Donner, A., Griffin, S., D'Ascanio, L., Pope, J., & Fowler, P. (2008). A randomized trial of arthroscopic surgery for osteoarthritis of the knee. *New England Journal of Medicine*, 359(11), 1097–1107.
- Legorreta, A., Silber, J., Costantino, G., Kobylinksi, R., & Zatz, S. (1993). Increased cholecystectomy rate after the introduction of laparoscopic cholecystectomy. *Journal of the American Medical Association*, 270(22), 1429–1432.
- Mendelson, D., Abramson, R., & Rubin, R. (1995). State involvement in medical technology assessment. *Health Affairs*, 14(2), 83–98.
- Newhouse, J. (1992). Medical Care Costs: How Much Welfare Loss? *The Journal of Economic Perspectives*, 6(3), 3–21.
- Owens, D., Sanders, G., Harris, R., McDonald, K., Heidenreich, P., Dembitzer, A., & Hlatky, M. (1997). Cost-effectiveness of implantable cardioverter defibrillators relative to amiodarone for prevention of sudden cardiac death. *Annals of Internal Medicine*, 126(1), 1–12.
- Pereira, J. (2003). Left behind—casualties of a changing job market; parting shot: to save on health-care costs, firms fire disabled workers. *Wall Street Journal*, 2003(A1).
- Ramsey, S., Moinpour, C., Lovato, L., Crowley, J., Grevstad, P., Presant, C., Rivkin, S., Kelly, K., & Gandara, D. (2002). Economic analysis of vinorelbine plus cisplatin versus paclitaxel plus carboplatin for advanced non-small-cell lung cancer. *Journal of the National Cancer Institute*, 94(4), 291–297.
- Reinhardt, U., Hussey, P., & Anderson, G. (2002). Cross-National Comparisons of Health Systems Using OECD Data, 1999. *Health Affairs*, 21(3), 169–181.
- Romley, J., Juday, T., Solomon, M., Seekins, D., Brookmeyer, R., & Goldman, D. (2014). Early HIV treatment led to life expectancy gains valued at \$80 billion for people infected in 1996–2009. *Health Affairs*, 33(3), 370–377.
- Sanders, G., Hlatky, M., & Owens, D. (2005). Cost-effectiveness of implantable cardioverterdefibrillators. *New England Journal of Medicine*, 353(14), 1471–1480.
- Schwartz, R., Luby, A., Scanlon, J., & Kellogg, R. (1994). Effect of Surfactant on Morbidity, Mortality, and Resource Use in Newborn Infants Weighing 500 to 1500 g. *New England Journal of Medicine*, 330(21), 1476–1480.
- Sorenson, C., Drummond, M., & Khan, B. (2013). Medical Technology as a key Driver of Rising Health Expenditures: Disentangling the Relationship. *ClinicoEconomics and Outcome Research*, 5, 235–245.
- Temel, J., Greer, J., Muzikansky, Gallagher, E., Admane, S., Jackson, V., Dahlin, C., Blinderman, C., Jacobsen, J., Pirl, W., Billings, J., & Lynch, T. (2010). Early Palliative Care for Patients with metastatic Non-Small-Cell Lung Cancer. *The New England Journal of Medicine*, 363(8), 733–742.
- Weiss, J., Saynina, O., McDonald, K., McClellan, M., & Hlatky, M. (2002). Effectiveness and cost-effectiveness of implantable cardioverter defibrillators in the treatment of ventricular arrhythmias among Medicare beneficiaries. *American Journal of Medicine*, 112(7), 519–527.
- Wolford, M., Palso K, Bercovitz, A., (2015). Hospitalization for Total Hip Replacement Among Inpatients Aged 45 and Over: United States, 2000–2010. HCHS Data Brief, No. 186.
- Wu, V., & Shen, Y. (2014). Long-Term Impact of Medicare payment Reductions on Patient Outcomes. *Health Services Research*, 49(5), 1596–1615.
- Wunsch, H., Linde-Zwirble, W., Harrison, D., Barnato, A., Rowan, K., & Angus, D. (2009). Use of intensive care services during terminal hospitalizations in England and the United States. *American Journal of Respiratory and Critical Care Medicine*, 180(9), 875–880.

Submit your manuscript to a SpringerOpen[®] journal and benefit from:

- Convenient online submission
- Rigorous peer review
- Immediate publication on acceptance
- Open access: articles freely available online
- High visibility within the field
- Retaining the copyright to your article

Submit your next manuscript at ► springeropen.com
