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TECHNOLOGY GROWTH AND EXPENDITURE GROWTH IN HEALTH CARE: RELATED LITERATURE

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ABSTRACT

Health care technology has contributed to rising survival rates, yet health care spending relative to GDP has also grown more rapidly than in all developed countries. While a particular new technology may either increase or decrease health care spending, researchers generally agree that, taken together, advances in medical technology have contributed to rising health care expenditure. The results of all review of economic health suggest that medical technology does have a significant role in health care expenditures. Thus, this article reviews the *literature* relating *medical* technology to *health care expenditure.*

KEYWORDS: Health Care Expenditure, Medical Technology, Developed Countries, Literature

INTRODUCTION

Economists and other observers often point to technology growth as the source of both trends. Newhouse (1992) considered a wide variety of factors that could reasonably have caused the rapid growth in health care expenditures, such as an aging population or the expansion of health insurance, and concluded that only technology growth could explain the vast majority of expenditure growth. Similarly, Cutler (2004) has argued that technological advances have generated both the far-reaching advances in longevity and the rapid growth in costs. Unfortunately, simply attaching the label of "technological growth" as the major cause of increases in health care expenditures doesn't get us much closer to understanding either the pathology of the disease – if it is a disease – or a meaningful way to address the problem – if it is a problem. Thus the principal focus of the paper is to better understand technological growth in health care and its impact on cost-growth and productivity improvements.

As a first step, we develop a demand-side model of health care, and like Hall and Jones (2007), show that rising income levels can optimally generate rapid growth in health care costs in a model with well functioning private insurance markets. But we also show that a rising role of government financing in health care can attenuate optimal growth as marginal tax rates rise.

A second broad category of medical technologies includes treatments and procedures whose benefits are substantial for at least some patients, but where the second derivative of the survival function is small in magnitude, meaning there is a large population of potential patients for whom health benefits converge towards zero as costs accumulate. Angioplasties with stents are a good example. In this procedure, a catheter is used to free blockages in the heart, and the stent, a wire mesh, is inserted to maintain blood flow. But there are many more patients where the value of angioplasty is less clear, for example among those with stable angina, or among those with little taste for the inherent risk

of surgery. Because there are more people in the latter category than in the former and the U.S. health care system compensates generously for all procedures, the marginal health benefits of this innovation are driven to zero and average productivity is diminished substantially. The third treatment category of technological innovations encompasses those treatments for which benefits are small or there is little scientific evidence of their value. This wide category includes treatments for which randomized trials indicate no benefit (vertebroplasty, in which cement is injected to stabilize vertebrae), as well as procedures whose effectiveness has not been evaluated (intensity-modulated radiation therapy for prostate cancer). There are also many decisions in this category that are made for the management of chronic illness.

We examine the parallel trends in technology growth and cost growth in health care. A theoretical model of growth and productivity leads to a typology of medical technology: highly effective and inexpensive innovations (antibiotics, or aspirin and beta blockers for cardiac care), more expensive yet effective treatments for appropriate patients (hip and knee replacements, surgical interventions for heart attack patients), and “gray area” treatments with uncertain clinical value (ICU days among chronically ill patients).

A common principle of all highly developed societies is the provision of at least basic health care services to each member of society by the public sector free of charge. As a result, in most industrialised countries, and notably in all Member States of the European Union, health care constitutes a significant share of public expenditure. At the present time, total expenditure on health care in the EU accounts for between 4 and 11% of GDP, out of which between 3 and 9% of GDP is financed from public sources. Moreover, as it accounts for between 10 and 18 % of total government spending, health care is therefore among the most significant items of social public expenditure.

FACTORS OF HEALTH CARE EXPENDITURE GROWTH

Public expenditure on health care has been growing over most of the second half of the 20th century, not only in absolute terms, but also in relation to the national income. This practically constant increase was a result of profound economic, institutional, social and technological changes which occurred all over the industrialised world. Such changes led to an increase in public awareness, expectations, and demand for health care on the one hand, and to improvements in capacity of both the medical industry and providers allowing them to offer better, faster and more reliable, albeit often more expensive, health care on the other hand.

There are a large number of factors which affect health care expenditure but the complexity of their interaction makes it difficult to draw precise lines which would identify their individual impact on health care expenditure growth. However, a number of econometric tools exist that can be used to make an approximate estimation of the relative impact of the respective variables on health care production and spending. This can be done on the basis of past observations but the main interest for policymakers, industry and the general public lies in the explanatory power of such an exercise and its usefulness in predicting future developments in the health care sector. Such is the purpose of the joint European Commission-Economic Policy Committee (EC-EPC) long-term projections of age-related items of social expenditure, which has been the inspiration and methodological basis for the analysis presented in this publication.

Taking as a basis the fundamental methodology used to project public health care expenditure, including mainly demand-side factors, such as demographic structure, income and health status of the population, the paper proposes to expand the model into the supply side by adding a supplementary module assessing the future impact of technological progress on public health care spending. Following a thorough analysis of the literature it concludes that there are no

scientifically reliable forecasts of the future developments in the medical technology. Consequently, the only feasible way to project future evolution of spending driven by technological factors seems to be an extrapolation of the past trends, with all the caution required, while interpreting and using the results in the future policy debate. The paper concentrates mainly on the impact of non-demographic factors, in particular on the impact of technology development on health care expenditure.

Demographic Structure

An ageing population is the most obvious factor behind increasing health care expenditure over the recent decades. Constantly growing life expectancy together with permanently low fertility rates have resulted in the gradual evolution of the demographic structure of populations that began with the last baby-boom period in the 1950's and 1960's and is not expect to shift sharply over the next decades. The effect of those changes has been a gradual increase in the share of older people in the population and – more recently – relative shrinkage of the young cohorts. This evolution has had an obvious impact on the demand for health care. Although the use of health care depends ultimately on the health status and not the age of a person itself, elderly people use health care more often and more intensively than young cohorts. Thus, the relative increase in the proportion of the elderly population contributes to the increase in demand for and expenditure on health care. Whilst this intuitive relationship is supported by most researchers, its strength is controversial.

Most econometric studies analysing the common impact of a series of factors attribute more importance to income, technology and institutional factors, agreeing that demographic change has a positive, though relatively minor impact on health care spending. Contributing to this stream, Oliveira Martins and de la Maisonneuve (2006) analysed the dynamics of health care expenditure by distinguishing between demographic and non-demographic factors. As the authors claim, the impact of demographic factors seemed to be quite weak while the impact of non-demographic factors prevailed over the last decades. The group of non-demographic factors is usually represented by income growth, relative-price movements in the supply of health services and, arguably most significant but at the same time least understood, medical technology.

Income

Most studies agree that the link between health care expenditure and the demographic structure is becoming weaker over time, as, despite generally improving health status, the consumption of health care keeps increasing. This phenomenon is due to the growing share of health care expenditure both in household budgets and in the public government spending which, in turn, is driven by the increasing awareness of the health status, growing public expectations on the level of health care provision guaranteed by the state and growing availability of new technologies allowing to tackle new, previously untreatable, diseases. While it is generally agreed that the growth in national income brings about the increase in health care spending, the strength of this relationship, or the value of income elasticity of demand, remains uncertain. As mentioned in the previous section, a different perspective must be taken when analysing the issue at individual and aggregate level. At the individual level, the existence of health insurance makes the demand for health care, to a large extent, independent of an individual's income, which means that demand is highly inelastic. At the aggregate level, the situation is different: health care spending depends mainly on the level and composition of government expenditure, which evolves in line with the wealth of society. Nonetheless, here again, existing studies have not managed to provide a clear estimate of the income elasticity coefficient.

On one hand, cross-country comparisons may intuitively suggest that health care is a luxury good, especially in the countries where health care is not yet a universally available public good (for example, the growth in health expenditure in the south- European countries in the 1960s and 1970s exceeded the rate of growth in more advanced economies of the EU, but also their own GDP growth rate). On the other hand, more recent time series data suggest the opposite, especially as universal provision of health care is a fact in most industrialised countries today (GDP growth can hardly be solely responsible for faster increase in health care expenditure). Econometric studies do not provide clear evidence for one or the other hypothesis, finding elasticity coefficients either greater or smaller than one.

The reasons for such variability in results could be due either to the different data sources, or to methodological problems. The outcomes of the empirical research studies were deeply influenced by advances in modern econometric techniques, e.g. time series and panel data techniques. In other words, the use of new methods and techniques often changed the view on existing theories and its empirical validation. Early analyses of the health care expenditure focused mainly on the relationship between this variable and national income, e.g. Culyer (1990) and Hitiris and Posnett (1992).

Although additional variables were proposed by theory, the empirical work did not verify their usefulness in predicting health care expenditure in general. Thus, the existence of a positive correlation between health care expenditure and aggregate income was the main and only robust conclusion at that time. As rather simple estimation techniques were applied in the above mentioned studies, the estimated parameters have been found to be potentially biased. In particular, the income elasticity was very often found to be higher than one, indicating that health care may have features of a luxury good (e.g. Newhouse, 1977).

Medical Technology

Medical technology is arguably the most important supply factor affecting the entire process of development, production, delivery and financing of health care. While precise estimates of its contribution to the improvement in longevity and health status are still lacking, recent studies tend to attach to it an ever more crucial role in the explanation of health expenditure. Technology, defined as ‘the drugs (pharmaceuticals and vaccines), medical equipment, health-care procedures, supportive systems, and the administrative systems that can tie all these disparate elements together’ are considered as the main driver of health care costs in today's developed societies. The first attempt to quantify the impact of technology is attributed to Newhouse (1992), who found that the bulk of health care expenditure growth in the industrialised countries can be attributed to technological growth. A great deal of further studies has supported Newhouse inference, see for example Okunade and Murthy (2002).

Recently, Oliveira Martins and de la Maisonneuve (2005) pointed out that since, over the last decades, health care spending has grown faster than the aggregate income, the effects of technology and relative prices seem to significantly affect health care expenditure development. Given the lack of empirical data and a uniform methodology to quantify the impact of medical technology on health care costs, three general approaches have been used in practice to estimate the size of its effect.

- The residual approach is based on the assumption that technology is responsible for all changes not accounted for by the other quantifiable factors. In practice, the effect of demographic changes, changes in health status, prices and income is subtracted from total increase in expenditure and the remaining part (residual) is attributed to changes in technology. Such a method avoids the difficulty of specifying the direct measure of technological

progress and covers all types of technology used in the process of health care provision. On the other hand, however, it provides only a rough, indirect and, often, overestimated measure of the effect of technological progress as the residual includes, apart from technology itself, a series of other not quantified factors, such as institutional setting, behaviour, environment, education, etc. The examples of the studies using residual approach include: Newhouse (1992), Peden and Freeland (1998), Oliveira Martins and de la Maisonneuve (2005) and the present study.

- The proxy approach uses an alternative measure to proxy the total impact of technology. An existing indicator is then introduced into the equation explaining the health care spending, assuming its changes follow the evolution of technology.
- Case studies analyses the effect of a specific technology on the cost of treating a particular medical condition. They can play an important role in the process of developing new drugs or technological applications, but their contribution to the analysis of overall health care costs is very limited. In this context, the most useful studies are those focusing on the most significant conditions (selected according to prevalence rate, contribution to overall mortality or disability, etc.), which can be extended to the wider spectrum of medical conditions. The examples of such studies include i.a. Cutler and McClellan (2001) where the costs and benefits of introducing a new technology were compared for five selected conditions, or Baker et al. (2003), where supply of ten selected technologies was compared to health care utilisation and spending.

Although empirical evidence clearly points to the cost-increasing effect of new technologies, whether a particular technology increases or decreases costs depends on its impact on unit cost and the level of use or on whether the treatment complements or replaces the existing methods. Broadly speaking, if the expected outcome is to treat in a better, faster and more efficient way diseases and medical conditions that have already been treatable before, the new technology is likely to reduce the use of other (less efficient/more costly) services and overall unit cost without changing the scope of treated population and therefore reduce total cost per patient. If the new method supplements the existing instrumentation and its purpose is to expand the treatment into the conditions that have not been treatable previously due to scientific (the methods of treatment are simply unknown) or economic (the methods of treatment are known, but enormous costs make it unfeasible on a larger scale) reasons, it will probably have a cost-increasing effect. Obviously, this picture is a highly schematic one and a number of other economic and behavioural mechanisms can influence and alter the budgetary effect of the new technologies, contingent on the legal and institutional setting currently in place. For example, in case of fixed budgets payment mechanisms, more cost-efficient technologies can hardly reduce overall expenditure simply because the providers will carry out proportionately more treatments at a lower unit cost to fulfil the budget (rebound effect).

On the other hand, extra savings may be expected if a decrease in the relative price of a given type of treatment (due to e.g. the introduction of a new technology) reduces the use of the other, more expensive, substitute types of care (substitution effect). Another classification (proposed by Thomas, 1975) of the new technologies brought to market follows their expected medical effect and allows to distinguish two general types. On the one hand, so-called 'halfway technologies' do not prevent or cure disease, but they simply treat the symptoms or, in extreme cases, aim at saving life while not improving health status. The use of such technologies leads to the extension of lifespan, but also to longer and more costly treatment. Thus in spite of obvious social and human gains, their financial impact is clearly negative. On the other hand,

'high technologies' offer prevention or complete cure, which typically decreases or eliminate the burden of disease and brings cost-efficient outcomes12. According to Weisbrod (1991), most technologies brought to market in the second half of the twentieth century (with the exception of vaccines) represented 'halfway technologies'. However, fast development of biomedicine over the last decade may give way to the Thomas specifies also the third group, 'non technologies' which are the procedures undertaken in case of diseases which are intractable or poorly understood.

Identification of the main factors behind the progress of medical technologies helps in understanding its budgetary effects. Creation and development of new technologies are driven by both demand and supply side forces. On the one hand, they are 'pulled' by consumer demand driven by disposable income and increasing expectations linked to the growing living standards. Demand for health care technology grows, as much as demand for health care in general, as the population becomes wealthier and more aware of the health care needs and new opportunities created by technological innovations. On the other hand, development of new technologies is 'pushed' on the supply side by science, researchers, medical industry and providers.

Practically all participants of the market for medical goods and services have stake in the development and fast diffusion of new, often high cost technologies13: the main users of technology, and thus customers for innovators, are not the patients themselves, but the hospitals and physicians; clinicians are often actively involved in the process of developing and assessing the medical technologies; hospital managers often find rapid adoption of new technologies rewarding in a competitive environment; public is strongly influenced by the news on the benefits of new technologies.

The supply of new technologies depends also on the type of health insurance contracts and the rules regulating the relationships between insurers and providers. Whether the system is supportive for investments in technological progress depends mainly on the definition of health care goods and services covered by insurance. If (i) the system is retrospective and cost-based (the amount of reimbursement is not specified ex-ante by a contract between insurer and patient or provider) thus allowing payments for all incurred costs and (ii) benefits covered by the insurance are not precisely specified as a list of existing procedures and drugs, the R&D sector has incentives to develop new technologies, as it has the guarantee that its investment will pay back. If, on the contrary, the system is prospective and defines ex-ante the budgets for health providers and the list of benefits to be reimbursed, industry does not invest in the new technologies, knowing that they cannot be practically adopted before an often lengthy and costly process of registering them as the reimbursed benefits is finished.

A strong factor affecting development of medical technology is also the level of competition between providers and insurers regulated by the law. On the one hand, the more freedom the patients have when choosing the provider and the type of treatment, the more incentives the providers have to differentiate their offer and supply the most effective and efficient treatments. On the other hand, in a highly standardised market for health insurance, any additional treatment or drug covered by an insurance contract may be a decisive factor encouraging patients to the sign it with the insurer offering the widest or most differentiated coverage. Progress in medical science and the development of new technologies strongly affect public expenditure on health care in most industrialised countries of the world. Although it is found to account for the highest share of spending growth, it is also the most difficult factor to quantify. Incomplete knowledge of the interactions between technology and other factors affecting health care expenditure constrains the reliability of past analysis.

Uncertainty surrounding future developments limits the predictive ability of the extrapolation of the past trends into the future. However, bearing in mind the caveats of such an exercise, the analysis of the past developments can teach us a lot about the interactions between technology and other factors. Moreover, an attempt to project their joint impact on the overall and public health care expenditure can serve as a good approximation of future needs of financial resources and expected pressure on public finances coming from this constantly developing and growing sector of activity.

A number of econometric tools were applied in order to estimate the expected impact of the technological progress on health care expenditures. Following the literature, a widely accepted specification of health care equation was used to estimate the annual trend growth rate of per capita health care expenditure for individual countries and pooled data.

DRIVERS OF HEALTH CARE COSTS – OVERVIEW OF THE LITERATURE

Notwithstanding the huge effort invested in the analysis of health care expenditure development and its determinants, to-date neither theoretical analysis nor empirical studies have provided unanimous conclusions. Thus, despite the significant efforts, an analysis of aggregate health care expenditure is an ongoing research topic. As for all public goods, the analysis of factors driving changes in health care expenditure differs, necessarily, between the micro and macro level. The existence of a number of legal and institutional restrictions regulating the provision of health care goods and services to the population constrains the functioning and alters the outcome of the market mechanisms driving individual citizens' and companies' behaviour at a micro level. In the context of health care, the universal health insurance coverage present - at least for a number of basic treatments - in practically all EU Member States, has arguably the largest impact on the individual behaviour of agents. In particular, universal coverage and high subsidies considerably reduce the elasticity of demand for health care with respect to both prices and income. In such a situation, while health care utilisation and spending is generally only linked to an individual's wealth to a limited degree, the market failure phenomena (moral hazard, information asymmetry) may drive patients to demand and providers to "produce" more health care than is justified by the actual health status. Those mechanisms do not work at the aggregate national level where income elasticity tends to be high, depending on the ability of the society to afford the high quality health care provided to each individual. On the other hand, even in the countries with the highest income, elasticity of overall public demand is limited by the budgetary caps, as health care is still mainly financed from public, limited sources.

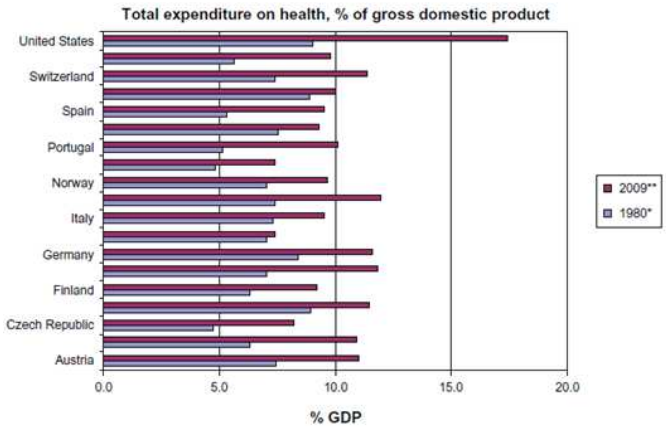
In sum, the analysis of drivers behind the evolution in health care spending is far from straightforward and must clearly distinguish between the macro and micro level, and take account of a complex network of interactions between patients, providers and payers as well as the division between public and private sector.

The general approach to health care expenditure dates back to the seminal analysis by Newhouse (1977 and 1992). Using a decomposition of the health care expenditure growth, he It is difficult to assess price elasticity at the aggregate level, except for the price of health care relative to the prices in the other sectors of economy.

Health care spending has risen at rates greater than gross domestic product in most OECD countries. In 2009, average health spending reached 9.5% of gross domestic product, up from 8.8% in 20081 (Figure 1). During the same time period, average per capita spending increased by an average of 3.8% in 2008 and 3.5% in 2009, with public spending on health growing at an even faster rate of 4.8% and 4.1%, respectively. For most countries, rising health expenditure is considered an enduring challenge and one that requires a complex balancing act between cost control, affordable and equitable access to beneficial treatments, and support for innovation.

However, analysts often point to advances in medical technology and their diffusion across health systems as the principal driver for burgeoning expenditures. This paper critically examines this conjecture, based on an analysis of a broad range of existing evidence on the relationship between medical technology diffusion and health expenditure. We strive to focus on medical devices, given the gap in the literature on their role in health expenditures, which has predominantly centered on pharmaceuticals, and because the sector has grown considerably in recent years. Not only are there substantially more medical technologies on the market, but they have grown increasingly sophisticated.

The paper is structured as follows. We first outline the methods used to review the literature, followed by a summary of the available evidence.



Notes: *All data from 1980 except for Czech Republic (1990), Hungary (1991), Italy (1998), Poland (1990), and Slovenia (1995); **all data from 2009, except for Portugal (2008). OECD Health Data 2011

Figure 1: Total Expenditure on Health as a Percentage of Gross Domestic Product (GDP) (1980–2009)

MATERIALS AND METHODS

A literature review was conducted to explore the current evidence base on the relationship between medical technology and health care expenditures. Unlike previous studies in this area, we considered a wide range of literature to ensure adequate coverage of different methodological approaches and ideological perspectives for assessing this relationship. The categories of literature included in the search and review included general and descriptive analyses, policy analyses, literature reviews, multivariate analyses, cost-effectiveness analyses, and cost impact studies of specific technologies. Table 1 presents and describes the various study types included in the review.

To identify relevant cost-effectiveness analyses across all medical technologies would be a considerable task. Therefore, we took advantage of two previously completed systematic reviews of economic evaluations of medical devices in the cardiology and orthopedic sectors, the two most significant markets for therapeutic devices.

In these reviews, we used the National Health Service Economic Evaluation Database for the searches, which contains structured reviews (abstracts) of full economic evaluations of health care treatments and programs. In these two previously conducted studies, we employed the following search terms “cardiology”, “cardiac rhythm management”, “cardiovascular”, “coronary stents”, “cardiac resychronization”, “implantable cardioverter defibrillators”, “orthopaedic”, “hip”, “knee”, “shoulder”, “ankle”, “elbow”, “arthroplasty”, and “joint”.

All the relevant abstracts were reviewed, from both the general literature review and the review of National

Health Service Economic Evaluation Database. Duplicate and irrelevant abstracts were identified and eliminated. Selected articles were reviewed according to a data extraction form, developed in Microsoft Excel, to standardize the review and facilitate subsequent analysis of the collated information.

The categories of information extraction included: basic bibliographic information; publication year; literature type (eg, descriptive analysis); study aims; technologies studied; study setting; methods employed; outcomes across health, costs/expenditures, and cost-effectiveness; and, stated conclusions and implications of the study. The information extracted was then analyzed for key themes across the domains interest (ie, impact of medical technology on costs or spending and factors influencing this relationship, and the methodological challenges noted in measuring such linkages).

A total of 86 studies were included in the review Table 1 provides a summary of general study details. The majority (52%) of studies were more qualitative in nature (eg, descriptive and policy analyses, literature reviews), followed by cost-effectiveness (40%) and multivariate (24%) analyses.

RESULTS

Although technological innovation is of great significance in health care and has been claimed to be a key driver of health spending, the review highlighted that research measuring the potential contributions of medical technology to rising health care costs has been relatively sparse. One possible reason for this neglect, and the predominant reliance on more descriptive or qualitative analyses among available studies, is that technology itself and its possible implications on health expenditures are insufficiently understood. Other reasons center on the often limited data available to explore this relationship and the complexities of measuring such associations, which we discuss further below.

The available evidence that does exist suggests that, in general, new medical technology is an important determinant in rising health care expenditures. Of the studies reviewed that attempted to quantify this relationship, mainly econometric studies, the overall impact (ie, proportion of the cost increase) ranges from approximately 25% to 75%, averaging at about 50%7,9,10,14–19 (Table 1).

While much of the quantitative evidence indeed substantiated the cost-increasing effect of new technology overall, the broader spectrum of evidence (eg, cost-effectiveness studies, descriptive analyses) suggests that the relationship between technological advances and health care expenditure is not straightforward or static. Rather, it should be understood as being complex, with a wide range of potential intervening factors that change and shift the dynamic of the association, depending on the particular circumstances.

For example, this relationship often differed across technologies, with some exerting more upward pressure on health care expenditure than others. Of 16 diseases (and subgroups) studied by Scitovski20 in a case study, new technology decreased costs in eight cases, increased costs in seven, and in one case had neutral effects. The use of “low-tech” technologies such as electrocardiography, laboratory tests, and x-rays stabilized or increased costs at a moderate pace, while the use of complex or sophisticated technologies and procedures such as cesarean section, new treatment modalities for breast cancer, and coronary bypass surgery substantially increased costs.

In another case study, Bryan et al found that technology that introduces computer-based information networks for imaging archiving increased annual hospital costs by 1.8%.

Table 1: Contributions of Selected Factors to Growth in Health Care

	Di Matteo	Jones	Smith et al	Peden and Freeland	Cutler	Newhouse
Life expectancy/aging	-9%	*	2%	6%-7%	2%	2%
Adninistrative costs	*	*	3%-10%	*	13%	*
Changes in financing	*	*	10%	4%-5%	10%	10%
Personal income growth	9%-20%	*	11%-18%	14%-18%	5%	<23%
Healmth care prices	*	*	11%-22%	*	19%	*
Technology	-65%	50%-75%	38%-62%	70%-75%	49%	>65%

Notes: *Not estimated; **included aging, but also "front page treatments" (ie, media coverage drives demand for expensive treatment), increased preventive and diagnostic activity, and consumers moving away from less expensive managed care products; ***included government mandates (including new mandated benefits) and federal and state regulatory requirements

For an existing service; expands the number of treatable conditions, in that it allows providers to treat conditions they previously could not treat or could not treat effectively or aggressively; intensifies level of use of the technology for the same condition; impacts the delivery of care (eg, improves the capacity of the system to treat more patients); broadens the definition of diseases; and extends life, for which each patient bears (or induces) additional years of health care consumption. For instance, with regards to increasing the indications and applications of the innovations, the initial use of imaging diagnostics (eg, x-rays, computed tomography, magnetic resonance) was initially targeted to specific organs and functions, but their application has extended to almost every part of the human body, resulting in increased spending 26. Further, some new technologies may allow lower unit costs (ie, treatment becomes cheaper) or cause less discomfort or complications, thereby offering the potential for cost savings. However, these benefits may lead to increased provision of services to persons who, without the new technology, may not have undergone a particular treatment.

DISCUSSIONS

The results of our review suggest that medical technology does have a significant role in health care expenditures, albeit a dynamic and complex one. However, there are limitations to the methodological approaches used in the available published literature, which introduce challenges to arriving at a clear assessment of such dynamics. For example, in terms of quantifying this link, the residual approach[1]can yield a reasonable indirect approximation of how medical technology relates to long-term growth in total health expenditure, but it can be sensitive to assumptions regarding the effects of other related factors (eg, personal income, health insurance coverage, technology development) and the dynamics between them[2]. This frequently leads to an overestimation of the effect of technology on spending. Another common method, i.e, the proxy approach[3] is only as good as the proxy indicator used to assimilate the impact of technology on spending. The use of time as a proxy measure for technological change, for example, not only captures such changes, but may also encapsulate variations in policy, patient experiences, preference, and expenditures[4].

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Another method, ie, the case study approach[5], is useful to explain the impact of certain medical technologies on health care costs, but there are problems of sampling and it is difficult to generalize to an aggregate or national level[6]. Consequently, most analysts using this approach have focused on the most significant conditions (eg, prevalent, contributing to high levels of mortality or disability), such as heart disease. These technical issues also characterize cost-effectiveness and cost impact analyses[7].

In addition to the limitations noted with individual approaches, there are technical issues shared across the various methods. Firstly, the results are frequently based on aggregate level data that are often subject to potential endogeneity and omit variable bias[8]. Secondly, as intimated above, several of these methods can depend on relatively simplified models dealing with highly complicated and interrelated parameters16[9] and can only arrive at conclusions about the collective effect of technology on health care spending, not on the contributions of specific technologies. Different types of technologies (eg, drugs versus medical devices) arguably impact health spending differently, particularly in terms of the associated changes in clinical practice that follow their adoption. For example, a recent study47 estimated that medical devices account for a relatively small share of national health expenditures (3%–5%), which have risen only slightly over the last 20 years, ie, a trend different from that of pharmaceuticals. Thirdly, across both quantitative and qualitative approaches, capturing the economic (and social) complexities surrounding the use of technology can be challenging, because it generally necessitates a complete understanding of the manner and magnitude of change in the clinical management pathway associated with treatment and follow-up. This process can occur over extended periods of time, and can have varying resource costs that can be both easy and difficult to measure[10].

Available studies are often focused on a narrow time window and the specific duration of the life cycle for a technology. Therefore, results from studies with longer or different time periods could vary. For instance, the price of medical technologies generally decreases over time, which would not be captured in shorter-term studies or those that happen to examine a given technology(s) close to initial launch. Similarly, technological advances occur simultaneously with changes in other factors that affect health care spending, such as personal income and health financing systems, which make it difficult to identify causality reliably, and exactly how technology itself affects spending growth. Finally, current methods cannot effectively demonstrate the cost impact that would result if availability of technology were reduced or eliminated. In the short-term, cost-savings may be achieved, while limited access to technology may result in higher costs in the long term due to the presence of disease that was not adequately treated owing to reliance on older, less-effective technologies or a complete lack of viable treatment alternatives.

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Before concluding, it is important to note a few limitations to this study. Firstly, while we strove to select and review only studies focused on medical technology, some studies, particularly certain types of econometric studies, looked at technology collectively. Therefore, for those studies, we were unable to distinguish the relative contribution of different types of technology (eg, drugs versus devices) to the proportion of spending attributed to technological innovation. Secondly, we focused our review of cost-effectiveness studies only on selected cardiology and orthopedic devices. Nevertheless, these particular sectors are arguably important markets and those most likely to have a cost impact.

CONCLUSIONS

Major technological advances in medical science have allowed health care providers to diagnose and treat illnesses in ways that were previously impossible. In general, such developments have tended to increase health care spending, which has been seen as an important policy concern, especially considering ever-limited health care budgets.

However, examining the link between medical technology and health expenditures is only one part of the picture. In order to understand better the dynamics between innovation and spending, it is important to assess whether and under what circumstances do investments in medical technology result in better value in health care. As Cutler and McClellan 25 assert, “it does not necessarily follow that technology change is therefore bad … costs of technology need to be compared with benefits before welfare statements can be made”. Given the current global economic situation, it is ever more important to ensure that we are attaining good value for money from the technologies developed.

To be sure, the question of whether medical technologies result in added value to the health care system is, of course, also difficult to answer. It depends on our ability to determine the value of output from the health services sector, and placing a value on longer or better quality of life is difficult to appraise. As a starting point, much more comparative research is needed to understand better which technologies work best and are most cost-effective, and under what circumstances. Indeed, as previously discussed, some of the cost-increasing effects of technology arise from inappropriate use, where new treatments are offered to patients for whom there is none to little clinical benefit.

Current efforts to support comparative effectiveness research in the US and health technology assessment in Europe and elsewhere may help to foster these aims. However, it is important to note that medical technologies introduce unique technical challenges to health technology assessment or comparative effectiveness research, so assessment methods should adequately account for or be developed to accommodate such aspects.55 Moreover, in addressing questions of value, such research should strive, where possible, to assess a broad range of potential benefits beyond clinical or therapeutic benefit, including value for money, higher quality of care, improved quality of life, greater efficiency in care delivery (eg, reduced length of stay, shifting care from inpatient to outpatient settings), and enhanced ability to work or return to work.

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