Estimating the causal impact of healthcare expenses on life expectancy at birth: Exploring an instrumental variable approach with hospital payment schemes in OECD countries, Central and Eastern Europe and Central Asia

Student: Juliana Koh Pei Hoon
Student number: 411342
Supervisor: Pieter Van Baal
Date: August 2016
Place: Rotterdam, Netherlands

TABLE OF CONTENTS

Estimating the causal impact of healthcare expenses on life expectancy at birth: An instrumental variable approach with hospital payment schemes in OECD countries, Central and Eastern Europe and Central Asia

Abstract:
This study estimates the causal impact of healthcare expenditures on life expectancy at birth using an instrumental variable approach. Instruments of Fee for Service (FFS) and Patient Based payments (PBP), hospital payment systems are used for healthcare expenditure per capita on aggregate country level data from 1990 – 2005 for 20 OECD and 28 Eastern Europe and Central Asia countries. Our results indicate a significant positive association of healthcare expenditure on life expectancy at birth in OECD countries. However, the results need to be aware of the challenge of a precise classification of hospital payment system, potential endogeniety of the proposed instruments, thus the overall reliability and validity of the instrument.

1: Introduction

In recent years, countries have been burdened by rising healthcare cost, compounded by a rapidly aging population (Heijink et al., 2013; Cutler, 2002; Wubulihasimu et al., 2015; Moreno-Serra and Wagstaff, 2001; Or, 20010). This has led to debate on the effectiveness of increasing healthcare expenditure versus other public health or broader policy programs like education, sanitation transportation that affect health outcomes (Nolte and Mckee, 2004). Cutler (2002) provides a good historical overview of the evolving healthcare cost landscape driven by polarizing equity and efficiency needs. The first movement was about ensuring healthcare access to all through delivery of healthcare coverage. This weighed heavily on the healthcare budget and cost was further accentuated by adoption of more technologically advanced medical care. The subsequent backlash drove cost management through rationing of technology, expenditure caps, encouragement of lower coverage insurance plans and incentivizing doctors to serve less. Although the regulations were successful in reigning in cost, this came at a price of decreased efficiency in healthcare service provision such as increased waiting time. Consequently, a third wave of transformation emerged through healthcare financing innovation in areas like hospital payment schemes, to promote a better balance between equity and efficiency concerns (Cutler, 2002).

Much research in this area of effectiveness of healthcare expenditure involves: exploring the value of such health care spending in its efficiency on health system performance and its contribution to health outcomes (Heijink et al., 2014; Or, 2001; Martin et al., 2008); examining the impact of various healthcare financing on healthcare expenditure and health outcomes (Wubulihasimu et al., 2015; Moreno-Serra and Smith, 2015; Moreno-Serra and Wagstaff,2010) ; establishing the determinants of health outcomes (Or, 2001; Nixon and Ulmann, 2006). Whilst the field of Health Technology Assessment has been able to prove the effectiveness of healthcare technologies in a micro context, especially on specific disease level, there has been mix evidence of macro level health care system expenditure on health outcomes (Or, 2001; Heijink et al., 2013; Martin et al., 2007).

Given the importance of the rising share of healthcare expenditure in GDP, estimating a causal effect of healthcare expenditure on health outcomes like QALY, life expectancy and amendable mortality rates is important for a better assessment of healthcare system performance, cost effectiveness and its efficiency. Achieving a causal relationship between healthcare expenditure and health outcomes will better shape and justify both demand and supply side healthcare financing policies. It will also serve to better inform the determinants of healthcare expenditure for policy making. Likewise, causal estimation facilitates more accurate international comparison of healthcare systems.

Estimating system wide healthcare expenditure causal effect on macro level health outcomes holds many challenges. These include: difficulty in disentangling the effects of health care spending versus other technological or epidemiological changes (Nolte and Mckee, 2004; Martin et al., 2007; Heijink et al., 2013); endogeniety problems due to heterogeneity in healthcare systems, varied healthcare expenses measurement, use of general health outcome which increases exposure to confounders (Martin et al., 2008; Gravelle and Backhouse, 1987; Or, 2001; Moreno-Serra and Wagstaff, 2010;Nixon and Ulmann,2006) and other determinants of health outcomes such as healthcare financing (Moreno-Serra and Wagstaff, 2010; Moreno-Serra and Smith, 2015, Wubulihasimu et al., 2015) and socio-economic factors (Heijink et al., 2013); challenge in extricating the impact of medical needs versus healthcare expenditure on health outcomes as differing needs drives variation in healthcare expenses(Martin et al., 2007). Other econometric modelling issues include reverse causality, and lagged effects of healthcare expenses on health outcomes (Heijink et al., 2013; Gravelle and Backhouse, 1987).

The aim of this research is to obtain an estimate of causal impact of healthcare expenditure on life expectancy at birth using an instrumental variable approach to address issues of confounders and reverse causality. Hospital payment schemes will be implemented as an instrumental variable for healthcare expenses. Hospitals and primary care are the biggest spenders in healthcare and hospital payment schemes has been known to impact both healthcare expenses and also health outcomes through affecting the amount patients pay out of pocket, utilization pattern across different types of providers (Or, 2001; Moreno-Serra and Wagstaff, 2010; Wubulihasimu et al., 2015). This study will seek to answer: What is the effect of hospital payment schemes on healthcare expenditure? ; What does using hospital payment scheme as IV for healthcare expenses reveal about the causal relationship between healthcare expenditure and life expectancy at birth? The main contribution of this study is to assess the viability of this proposed FFS and PBP hospital payment as an instrument to healthcare expenses for causal impact on life expectancy at birth.

The following section describes the theory on hospital payment systems and hypotheses of this study. Section 3 presents the outcome variables, data collection method and the model specifications. Results and robustness check with alternative hospital classification systems are examined in Section 4. The study concludes with discussions and limitations in Section 5.

2: Hospital payment systems

2.1 Theory

Hospital payment schemes are an integral part of supply side incentives, thereby influencing healthcare expenses and possibly also health outcomes (Ellis et al., 2007; Or, 2001). Payment schemes affect national healthcare expenses through incentivizing providers to engage in cost control, price setting and also changing the competitive landscape (Ellis et al., 2007). Similarly, health outcomes are in part a consequence of the provider's response to constraints or opportunities of the payment schemes in their provision of quality and range of services (Moreno –Serra and Wagstaff, 2010; Ellis et al., 2007; Or, 2001; Wubulihasimu et al., 2015).

In general, there are three broad types of classification of hospital payment schemes: Fixed Budget (FB) captures provider characteristics and an annual budget is paid based on hospital sizes which may be defined by the number of beds or number of patients served. This is irrespective of type of patients or services provided; Fee for Service (FFS) reflects service characteristics regardless of from who and for whom it is provided for. Doctor's fees are typically set by payers and cost of resources and equipment are reimbursed at the end of the year without necessarily having an audit on how the resources has been used before reimbursement (Ellis et al., 2007); Patient based payment (PBP or DRG) are based on giving a fixed sum of money to the hospital for each patient diagnostic related group and independent of service or provider characteristics. Akin to a capitation system in doctors payment, it does not depend on the type of services provided or the quantity of the services, just on the number of patients in a particular diagnostic related group (Moreno –Serra and Wagstaff, 2010; Ellis et al., 2007; Or, 2001; Wubulihasimu et al., 2015).

Literature from Moreno-Serra and Wagstaff (2010), Ellis et al., (2007), Wubulihasimu et al., (2015) discusses the multi-varied impact of incentives. FFS and PBP may raise healthcare cost through supplier induced demand and over -provision of service with no quality improvement. These systems also encourage selection of low risk patients, reduced effort, quality and coordination, resulting in lowered health outcomes (Ellis et al., 2007). PBP may also engage in cost cutting or up-coding to increase profits. In contrast, Fixed Budget payment system allow for the payer to have better control of healthcare cost. However, it may still not encourage better quality of care as physicians may engage in selection of low risk patients and provision of base level service to increase profitability. There is also little incentive to coordinate across the healthcare system with other providers (Ellis et al., 2007).

It is not easy to disentangle and establish a permanent definitive direction of the overall outcome of the impact of hospital payment schemes on healthcare cost and health outcomes. Much of it depends on the scenario. The heart of complex interaction of hospital payment systems on health outcomes lies in the context of the demand and supply of the hospital provider. When exposed to hospital reforms from FB to FFS, a hospital currently at optimal level of service provision, maybe encouraged to over treat with adverse effect on health outcomes, especially if fees are higher than cost (Ellis et al., 2007). Alternatively, the hospital payment scheme reform for a sub optimal level of service provider may improve health outcomes by closing waiting time gaps (Wubulihasimu et al., 2015). These payment reforms also affect macro-level competitive landscape - the types of incentives may transform competitive landscape by encouraging mergers between providers and the size of incentives payments may also affect the number of entrants to the market (Ellis et al., 2007; Moreno-Serra and Wagstaff, 2010). Eventually, private demand are affected by the subsequent quality and price offered and influenced by payment systems (Ellis et al., 2007). Another dynamic at play is the role of demand side healthcare financing like social health insurance (SHI) or taxation and its connections with supply side financing and healthcare expenditure (Ellis et al., 2007; Wagstaff, 2009). The interaction between demand and supply side financing may be illustrated with such an example: Social health insurance may promote liberal use of the healthcare system with no constraints to access for the individual. This, together with supplier induced demand from an FFS payment scheme may further drive an increase in healthcare expenditure. Wagstaff (2009) flagged the typical association of SHI demand side financing with supply side FFS or PBP hospital payment schemes. In contrast, financing via taxation is more strongly associated with FB hospital payment schemes.

Currently, the relationship of healthcare expenditure on health outcome has been estimated via cross sectional studies amongst different countries (Cochrane et al., 1978), sub provinces within a country over time (Cremeiux et al., 1999; Martin et al., 2007), panel data across countries and time period (Heijink et al., 2013; Or, 2001) or healthcare budget program evaluation (Marin et al., 2007). Most studies model a macro health production function or evaluate healthcare expenses and outcome specifically for certain diseases. Exogeniety of some variables have also been assumed. Beyond this, methods of IV on healthcare expenses, modelling of reverse causality (Moreno-Serra and Smith, 2015; Martin et al., 2009), controlling for omitted variables (Heijink et al., 2013), use of lags, time trend, country dummies (Heijink et al., 2013) have been used to address endogeniety issues.

Findings on relationship between healthcare expenditure and health outcomes have been mixed. Cochrane et al., (1978) found no significant impact of healthcare expenses on health outcome even after controlling for confounders. However, Heijink et al., (2013) shown 1% increase in health care expenditure decreases avoidable mortality by 0.5% and also a significant lagged effect of healthcare expenses. Martin et al., (2007) established a causal effect of healthcare expenditure on health outcomes with each life year gain costing 13,100 pound for cancer. A ten province study in Canada revealed lower healthcare spending increases infant mortality and lowers life expectancy (Cremeiux et al., 1999).

In this study, the IV of both FFS and PBP will be used to explore the association and a potential causal relationship of healthcare expenses on life expectancy at birth based solely on the variations in hospital payment schemes impacting healthcare expenses**.** Whilst a valid instrument requires its true exogeniety to be uncorrelated with error term, it is not possible to test for it. Evidence from various studies (Wubulihasimu et al., 2015; Moreno-Serra and Wagstaff, 2010; Heijink et al., 2013; Gravelle et al., 2003; Gerdtham and Jönsson, 2000; Wagstaff, 2009; Or, 2001) support the influence of hospital payment systems on healthcare expenditure, thereby the potential reliability and validity of these proposed instruments for healthcare expenditure per capita: Empirical evidence of hospital payment schemes and its reform impact on healthcare expenses; The incentives provided by the hospital reforms drive supplier induced demand and various strategies like reducing number of night stays and choice of expensive treatment provide support that hospital payment schemes affect health outcomes only through healthcare expenditure; Hospitals and primary care are the biggest spenders in healthcare and hospital payment schemes.

However, the proposed instruments of FFS and PBP may not be truly exogenous as it may still directly influence health outcomes. Wubulihasimu et al., 2015 have found empirical evidence of hospital payment schemes and its reform on health outcomes like infant mortality and amendable mortality. Although these are different health outcomes than the ones chosen for this study, it provides a potential inclination of hospital payment systems to directly influence other health outcomes too. Moreover, there may be potential omitted variables which causes potential endogeniety of proposed FFS and PBP instruments such as demand side healthcare financing systems, self- assessed health, lifestyle habits and lifestyle diseases. These, omitted variables may potentially be addressed through controlling for individual country heterogeneity and time dummies in our IV estimation. The effectiveness of these instruments may also be questioned if there is room for probable reverse causality of health outcomes with hospital payment systems. Although, there many likely caveats to the reliability and validity of FFS and PBP hospital payment systems as instruments for healthcare expenditure, for the curiosity of science, we would like to still proceed to study and assess the viability and outcomes of using this proposed FFS and PBP instruments, for the purpose of understanding it further for future research.

Life expectancy at birth is chosen to be the summary measure of population health outcome as it is universal and can be collected across countries. It has advantages of reflecting time and translation of mortality risk at different ages and typically of large samples (Murray et al., 2000). However, it does not account for the impact of healthcare expenditure on morbidity and quality of life measures (Murray et al., 2000).

2.2 Hypotheses

Supporting theory on hospital payment system in section 2, Wubulihasimu et al., (2015) found FFS to increase healthcare spending and Morena-Serra and Wagstaff (2009) study revealed switch from FB to FFS vs. PBP increased healthcare expense by 18% and 11% respectively - attributed to FFS incentivizing patients longer in stay with better quality of care. (Morena-Serra and Wagstaff, 2009). Accordingly, we hypothesize FFS and PBP hospital payment schemes to increase healthcare expenditure per capita compared to fixed budget payment schemes.

Secondly, we expect additional healthcare expenses caused by hospital payment schemes variation to increase life expectancy at birth. The increase in healthcare expenditure driven by FFS or PBP may lead to provision of better quality care and reduced waiting time as doctors and hospitals strive to maintain good reputation and to increase the number of patients they cater to (Ellis et al., 2007). Such quality improvement and access to care, whilst increasing healthcare expenses may lead to a positive impact on Life Expectancy at birth. In contrast, a fixed budget payment system may not motivate providers to give more services, but encourage cost cutting and risk selection of patients, leading to negative impact on life expectancy at birth, albeit with lower healthcare expenditure (Wubulihasimu et al., 2015; Ellis et al., 2007). However, there may also exist a potential opposite effect of FFS or PBP system driving up healthcare cost, not being complemented with an increase in Life expectancy at birth. Providers in these systems engaging in supplier induced demand may cut back on care for customer like decreasing number of night stays and giving unnecessary high cost treatment to raise profits (Ellis et al., 2007; Morena-Serra and Wagstaff, 2009).

To form our expectations for the on balance, expected sign of increase healthcare expenditure on life expectancy at birth, we tapped into previous empirical evidence to provide support for a positive impact of healthcare expenditure on life expectancy at birth. FFS was found to decrease infant mortality and PBP decreases amendable mortality and increase life expectancy at age at 65 (Wubulihasimu et al., 2015). Heijink et al., (2013) showed a 1% increase in health care expenditure decreases avoidable mortality by 0.5% and also a significant lag effect of healthcare expenses. These empirical evidences support postulation of healthcare expenses being positively influenced by variations in hospital payment schemes to affect health outcomes.

In sum, we hypothesize: FFS and PBP hospital payment schemes to increase healthcare expenditure per capita compared to fixed budget hospital payment schemes; Additional healthcare expenses caused by FFS and PBP hospital payment schemes variation increases life expectancy at birth.

3: Data collection and method

3.1Variables

Outcome variable:
The outcome variable of this study is life expectancy at birth. Life expectancy at birth can be calculated using period or cohort method. In this study, since we measure the instantaneous effects of healthcare expenditure on life expectancy at birth. The period method for measuring life expectancy at birth is based on age specific death rates of a specific period. This data is obtained from OECD Health, and WHO all health data.

Life expectancy at birth is chosen as it is a widely used variable with access to more observations in number of years and countries. However, its entails characteristic weaknesses of a general outcome variable, introducing many confounders (Or, 2001; Heijink et al., 2013) and does not capture morbidity or quality of life aspects. Nonetheless, in search of a universal health outcome variable that exist across the 48 countries, as well as its potential exogeniety with the chosen IV of hospital payment system, life expectancy at birth serves its purpose for this study.

Independent variables:
Total healthcare expense adjusted for purchasing power parity is a key variable of the research question. Heijink et al., (2013) justifies use of GDP PPP attributing the difference in inflation between the healthcare sector and other parts of the economy being in part due to health policy. Other confounders controlled for include: GDP per capita (excluding healthcare expenditure)- national income affects both healthcare expenses and life expectancy at birth (Wubulihasimu et al., 2015; Moreno-Serra and Wagstaff, 2010); percentage of population older than 65 y.o – this variable is controlled for as it affects both healthcare expenditure and life expectancy at birth. Health care expenses tend to increase with age, especially when one comes closer to time to death and much of hospital expenses are targeted at this population. Moreover, mortality rates tend to be higher amongst the older age group (Zweifel et al., 1999; Wubulihasimu et al., 2015; Moreno-Serra and Wagstaff, 2010). Additionally, a time trend year dummy variable is added to capture factors that affect all countries like technological innovation that leads to shift in the health production function (Heijink et al, 2013). Country dummies are also included to remove time invariant country heterogeneity like healthcare expense measurements and cultural, socio-economic aspects, for better international comparisons (Heijink et al., 2013; Martin et al., 2007)

Instrumental variable: Hospital payment system
As discussed in section 2.1, FFS and PBP hospital payment systems will serve as an IV for healthcare expenditure versus fixed budget hospital payment scheme.

3.2 Data source and description

We use aggregate country level data from 1990 – 2005 for 20 OECD and 28 Eastern Europe and Central Asia countries. The selection of countries and years are identical to the two papers Wubulihasimu et al., (2015) and Moreno-Serra and Wagstaff, (2010). Hospital payment system classification in 28 Eastern Europe and Central Asia countries are sourced from Wagstaff, Moreno Serra (2010) paper on “System wide impacts of hospital payment reforms: Evidence from Central and Eastern Europe and Central Asia", which were based on WHO Health in Transit and Country reports and internal World Bank discussions. Similarly, classification of hospital payment systems for the 20 OECD countries replicates Wubulihasimu et al., (2015) paper "The impact of hospital payment schemes on healthcare and mortality: Evidence from hospital payment reforms in OECD countries". This was built on Wagstaff and Moreno Serra (2010) classification method and WHO Health in Transit. The overall classification used is summarized in (Table 2). All other data for 28 Eastern Europe and Central Asia countries on annual total health care expenses per capita (2011 constant international dollars, purchasing parity adjusted), GDP per capital (measured in constant 2011 International dollars, purchasing parity adjusted), and share of population more than age 65 years old are sourced from World Bank World Development Indicator (WDI data base). The same measures in constant 2010 data, purchasing parity adjusted are obtained from OECD health data, 2012 for the 20 OECD countries. Outcome variable life expectancy at birth was obtained from World Health Organization (Health for all database) for all countries.

There are a total of 720 observations, with 48 countries across 15 time periods of years 1990 – 2004. The data is balanced. Mean life expectancy is 73.82 years old, being higher in the OECD countries at 77.96 years old. Mean healthcare expenditure per capita is 1,366.245 USD per capita. OECD countries spend on average 2,273.19 USD per capita on healthcare compared to a much lower average in Central/Eastern Europe and Central Asia at 426.9 USD per capita. On average, GDP per capital is 13,249 USD per capita adjusted for PPP with OECD countries having 25,396.49 USD per capita and Central/Eastern Europe and Central Asia with 3,735.1 USD per capita. On average, the share of population above 65 years old is 12.11%, with OECD having a high proportion of elderly population at 14.65% versus Central/Eastern Europe and Central Asia at 10.29%. Although there is bigger between than within variation in the data, there is still substantial within variation in the data. Taking the ratio of the within variation with the mean: Healthcare expenditure increased by 20% within the period of 1990-2004 with 16.1% for OECD countries and 28% for Central/Eastern Europe and Central Asia; Life expectancy at birth increased by 1.6% with 1.3% for OECD countries and 1.9% for Central/Eastern Europe and Central Asia; GDP per capita increased by 26.3% with 20.5% for OECD countries and 18.6% for Central/Eastern Europe and Central Asia. Table 1 describes the data. There are 140 missing observations for healthcare expenditure per capital from Central/Eastern Europe and Central Asia in years 1990-1994. Summary of missing values can be found in Appendix 1.

Table 1: Descriptive statistics

	Mean	Min	Max	SD between variation	SD within variation
Life expectancy at birth					
All 48 countries	73.82	61.84	81.44	4.26	1.19
OECD countries	77.96	74.06	81.44	1.036	1.01
Central/East Europe and Central Asia countries	70.6	61.84	77.55	2.722	1.31
Healthcare expenditure per capita					
All 48 countries	1366.245	23.97	3956	1026.5	274.06
OECD countries	2273.19	923.23	3986	550.64	366.13
Central/East Europe and Central Asia countries	426.9	23.97	1886.91	312.66	119.652
GDP per capita					
All 48 countries	13249.62	205.612	65206	11688.2	3484.26
OECD countries	25396.49	11198.2	65206	6212.7	5203.11
Central/East Europe and Central Asia countries	3735.1	205.61	17500.15	3585.7	695.66
Share of population above age 65 years old					
All 48 countries	12.1137	3.542	19.1	3.727	0.977
OECD countries	14.65	10.5	19.1	1.797	0.728
Central/East Europe and Central Asia countries	10.296	3.542	17.3	3.7	1.12

Table 2: Hospital payment schemes in 20 OECD and 28 Central and Eastern Europe, Central Asia countries

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Albania	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
Armenia	FB	FB	FB	FB	FB	FB	FB	FB	PBP	PBP	PBP	PBP	PBP	PBP	PBP
Azerbaijan	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
Belarus	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	.	.	.	.
Bosnia and Herzegovina	FB	FB	.	.	.	.	.	FB	FB	FB	FB	FB	FB	FB	FB
Bulgaria	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	PBP	PBP	PBP	PBP
Croatia	FB	FB	FB	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS
Czech Republic	FB	FB	FB	FFS	FFS	FFS	FFS	.	.	.	.	PBP	PBP	PBP	PBP
Estonia	FB	FB	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS
Georgia	FB	FB	FB	FB	FB	FB	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP
Hungary	FB	FB	FB	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP
Kazakhstan	FB	FB	FB	FB	FB	FB	FB	FB	FB	PBP	PBP	PBP	PBP	PBP	PBP
KyrgyzR	FB	FB	FB	FB	FB	FB	FB	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP
Latvia	FB	FB	FB	FB	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS
Lithuania	FB	FB	FB	FB	FB	FB	FB	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP
Macedonia	FB	FFS	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
Moldova	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
Poland	FB	FB	FB	FB	FB	FB	FB	FB	FB	FFS	PBP	PBP	PBP	PBP	PBP
Romania	FB	FB	FB	FB	FB	FB	FB	FB	FB	FFS	FFS	FFS	FFS	FFS	FFS
Russianfed	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
SerbiaMontenegro	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
slovakR	FB	FB	FB	FFS	FFS	FFS	FFS	FFS	FFS	FB	FB	FB	PBP	PBP	PBP
Slovenia	FB	FB	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	PBP	PBP	PBP	PBP	PBP
Taijkistan	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
Turkey	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
Turkmenistan	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
Ukraine	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
Uzbekistan	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
Australia	FB	FB	FB	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP
Austria	FB	FB	FB	FB	FB	FB	FB	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP
Belgium	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	PBP	PBP	PBP
Canada	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
Denmark	FB	FB	FB	FB	FB	FB	FB	FB	FB	PBP	PBP	PBP	PBP	PBP	PBP
Finland	FB	FB	FB	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	PBP	PBP	PBP	PBP
France	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	PBP
Germany	FFS	FFS	FFS	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	PBP
Greece	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS
Iceland	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
Ireland	FB	FB	FB	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP
Italy	FB	FB	FB	FB	FB	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP
Luxemburg	FFS	FFS	FFS	FFS	FFS	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
Netherlands	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FFS	FFS	FFS	FFS
Norway	FB	FB	FB	FB	FB	FB	FB	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP
Portugal	FB	FB	FB	FB	FB	FB	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP
Spain	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
Sweden	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	PBP	PBP	PBP
Switzerland	FFS	FFS	FFS	FFS	FFS	FFS	FB	FB	FB	FB	FB	FB	FB	PBP	PBP
UK	FFS	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB

3.3 Model specification

To estimate the causal impact of healthcare expenditure per capita on life expectancy at birth, this study builds on Wubulihasimu et al., (2015) and Moreno-Serra and Wagstaff, (2010) using Fixed Effects model on panel data from 1990- 2005 for 20 OECD and 28 Eastern Europe and Central Asia countries. We follow Wubulihasimu et al., (2015) and Moreno-Serra and Wagstaff (2010) and literature (Gerdtham and Jönsson, 2000) to control for time varying country specific confounders of GDP per capita, proportion of population aged 65 and older, country dummies to capture time invariant unobserved variables that correlate with healthcare expenses, and time trend year dummies to capture variables that affect all countries across time. Furthermore, the data will be analyze on all log transformed variables, with the exception of dummy variables like FFS, PBP hospital payment systems and time trend year dummies, to allow for interpretation as elasticities (Heijink et al., 2013; Wubulihasimu et al., 2015; Moreno-Serra and Wagstaff, 2010). Fix effects model has been chosen to control for time invariant heterogeneity. The model for estimation is expressed as:

$$LE_{it} = \beta_0 + \beta_1 ln_{HCEit} + \beta_2 ln_{GDPit} + \beta_3 ln_{share\_of\_population\_65it} + \alpha_t + \gamma_i + \varepsilon_{it} \qquad (1)$$

Where LE_{it} is the health outcome of life expectancy at birth, ln_{HCEit}, ln_{GDPit}, $ln_{share\_of\_population\_65it}$ are the confounders, and α_t is the year specific time dummy, and $\gamma_i$country specific dummy. Using Fixed Effects estimation, all country level time invariant effects, $\gamma_i$will drop out of the model estimate. Fixed effects estimation will be based on the within variation captured by the difference of the variable and its mean (Wooldridge, 2014; Wubulihasimu et al., 2015; Moreno-Serra and Smith, 2015).

To examine the relevance and potential validity of the chosen FFS and PBP hospital payment system instruments for healthcare expenditure, we will estimate the effects of hospital payment systems on healthcare expenditure controlling for confounders:

$$Ln_{HCEit} = \beta_0 + \beta_1 ln_{GDPit} + \beta_2 ln_{share\_of\_population\_65it} + \sigma_{FFSit} + \delta_{PBPit} + \alpha_t + \gamma_i + \varepsilon_{it} \qquad (2)$$

Where Ln_{HCEit} is Ln Healthcare expenditure, and following Wubulihasimu et al., 2015, $FFSit$ and $PBPit$ are hospital payment system dummies in equation (2). Similar as in equation (1), confounders of ln_{GDPit}, $ln_{share\_of\_population\_65it}$, α_t year specific time dummy and γ_i country specific dummy are controlled for. Again, all country level time invariant effects will drop out of the fixed effects model estimate (Wooldridge, 2014; Wubulihasimu et al., 2015; Moreno-Serra and Smith, 2015). IV estimation will be conducted using the FFS and PBP as instruments.

The process of using instrumental variable estimation involves two stages. The first stage of the regression regresses the instrument $FFSit$ and $PBPit$ on the instrumented variable Ln_{HCEit}, as in equation (2). The predicted value of Ln_{HCEit} is obtained and fed back into the second stage of the regression, equation (3) for the IV estimation.

$$LE_{it} = \beta_0 + \beta_1 ln\widehat{HCEit} + \beta_2 ln_{GDPit} + \beta_3 ln_{share\_of\_population\_65it} + \alpha_t + \gamma_i + \varepsilon_{it} \qquad (3)$$

3.4 Specification test

Model estimation will be carried out for all countries and subsequently only for OECD and Eastern/Central Europe, Central Asia countries. Results for these will be presented and compared in section 4.1. To further check for robustness, we will also be running the analysis using an alternative hospital classification system as presented in Wubulihasimu et al., (2015) and Moreno-Serra and Wagstaff, (2010). This will be presented in section 4.2 on robustness and sensitivity check.

Fixed effects estimation has been selected for the following reasons: 1. Fixed effects is theoretically less restrictive than Random effects as Fixed effects estimation allow for correlation of individual specific effects with the independent X variables, whereas Random effects assumes the fixed individual heterogeneity are uncorrelated with the independent X variables (Wooldridge, 2014); 2. Following the empirical models used in Wubulihasimu et al., (2015) and Moreno-Serra and Wagstaff, (2010) of difference in difference nature - Fixed Effects and First Difference; 3. Haussmann test without correction of robust standard errors shows significant difference in coefficients of Random versus Fixed effects. Using Random effects will be biased and inconsistent (Wooldridge, 2014).

Due to the nature of time series panel data, we correct for heteroskedascity with robust White standard error (Wooldridge, 2014; Wubulihasimu et al., 2015) and serial correlation of error with cluster option (Wooldridge, 2014; Wubulihasimu et al., 2015) in all estimation. F test of joint significance and Reset test was conducted to check for model misspecification and results showed the model estimation of base equation (1) cannot be rejected for correct specification at 5% level of significance and the selected variables are sufficient for purpose of this study.

In assessing relevance and validity of the chosen hospital payment system IV, correlation of healthcare expenditure and hospital payment system of FFS, PBP are carried out. The results support our expected hypothesized directions. FFS and PBP hospital payment system positively correlate with healthcare expenditure per capita on all country level data (Appendix 2). We further conducted test of relevance of IV with joint F test and Durbin, Wu-Haussmann test of exogeniety of the regressors to assess if the model is exogenous, whereby the use of OLS is preferred to IV as use of IV will be inefficient (Wooldridge, 2014). We will not be able to fully test if the IV of hospital payment system is valid and not correlated to the error term. Results of these test will be discussed in the next section.

4: Results

4.1 Key findings

4.1.1 Healthcare expenditure

We present the results of the estimation of impact of healthcare expenditure per capita on life expectancy at birth (equation 1) in Table 3. Increase in healthcare expenditure per capita has the expected positive sign on life expectancy at birth for all countries. A 1% increase in healthcare expenditure per capita increases life expectancy at birth by: 0.00683% for all countries, 0.0104% for OECD countries; 0.0104% for Central/ Eastern Europe and Central Asia. However, this is not significant at 5% level. The effects of healthcare expenditure per capita on life expectancy at birth is lower when all countries are put together then if the countries were estimated separately. This is in part due to the different within variation in the overall versus separate countries samples.

By dividing the within variation with the mean of healthcare expenditure per capita in all countries, healthcare expenditure per capita increase by about 20% in this period of 1990- 2004. Based on the model of equation (1), this led to an overall impact of an increase in 0.1011 life years for each individual given an average of 20% change in healthcare expenditure per capita in this period. Similarly between years 1990 – 2004: Central/Eastern Europe/ Central Asia, there is an increase of 0.2170 life years per individual given an average of 28% increase in healthcare expenditure per capita; OCED countries experienced an average of 16.1% change in healthcare expenditure per capita and an increase of 0.1237 life years. A 1% increase in GDP per capita significantly decreases life expectancy at birth by 0.016% (p value: 0.044) in all countries analysis. Whilst it may seem contrary to expectations as an increase in GDP in a country is expected to reflect better quality of life and thus in an increase in life expectancy at birth, we have taken GDP excluding healthcare expenditure to reduce potential multicollinearity issues. In this instance, effects of healthcare expenditure embedded in the non-corrected GDP per capita are captured independently in the healthcare expenditure per capita variable.

Table 3: Estimated effects of healthcare expenditure per capita on life expectancy at birth

Dependent variable	All countries N=541	Central/Eastern Europe/Central Asia N=253	OECD N=288
Healthcare expenditure per capita	0.00683	0.01049	0.0104
	[0.00537]	[0.0080]	[0.0118]
GDP per capital (exclude healthcare expenditure)	-0.01623	-0.00837	-0.00875
	[0.0078]**	[0.0131]	[0.0095]
Share of population above 65 years old	-0.00145	-0.0058	0.00025
	[0.0014]	[0.0042]	[0.0012]

*significant at 0.10 significance level **significant at 0.05 significance level ***significant at 0.01 significance level

4.1.2 Hospital payment systems

Table 4 shows the estimates of impact of FFS and PBP hospital payment systems on healthcare expenditure per capita (equation 2). In line with our initial hypothesis, signs of coefficients are positive in the estimation for all countries sample and Central/Eastern Europe/Central Asia sample. However, it is significant only in Central/Eastern Europe/Central Asia sample. Having a FFS or PBP hospital payment system increases healthcare expenditure per capita compared to a fixed budget, as providers may be incentivized to raise cost through supplier induced demand without necessarily delivering on quality improvement. There may also be up-coding by PBP system hospital providers for increased revenues. At 10% level of significance, FFS hospital payment system increases healthcare expenditure per capita by 0.086% compared to Fixed Budget.

On the hand, FFS significantly decreases healthcare expenditure per capital in OECD countries by 0.0392%. This finding is different from Wubulihasimu et al., (2015) who found a positive effect of 0.0074% of FFS on healthcare expenditure per capita for OECD countries. This could be due to the difference in the time period included in this study of only 1990-2004 versus their paper which estimated a similar model using longer time span from years 1980 to 2009, potentially capturing more changes and impact of FFS on healthcare expenses per capita. Moreover, some OECD countries like Germany, Switzerland and Netherlands have also started to engaged in managed care to help control healthcare cost through contracts between insurers and providers to limit moral hazards and supplier induced demand brought forth by FFS payment system incentives (Shmueli et al., 2015; Barker, 1995). This to some extent may explain the negative impact of FFS payment systems on healthcare expenditure per capita found in this research. This is supported by findings in a study on HMOs and FFS, evidence from Medicare by Barker (1995) where the author found FFS to be concave in HMOs market share and expenditure decreasing in HMOs market shares.

Table 4: Estimated effects of hospital payment systems FFS/PBP on healthcare expenditure per capita

Dependent variable	All countries N=560	Central/Eastern Europe/Central Asia N=270	OECD N=290
FFS	0.0108	0.08651	-0.0392
	[0.02968]	[0.0306]***	[0.0127]***
PBP	0.0299	0.0727	0.0163
	[0.0333]	[0.0545]	[0.0289]

*significant at 0.10 significance level **significant at 0.05 significance level ***significant at 0.01 significance level

4.1.3 Causal effect of healthcare expenditure on life expectancy at birth

We present the results of the IV regression in for health outcome of life expectancy at birth. Table 5 shows the IV estimates are obtained by using FFS and PBP hospital system (equations 2 and 3). The first column shows results of the fixed effects least square regression and the second column the IV estimates of the same. The impact of an increase of 1% of healthcare expenditure per capita on life expectancy at birth has a bigger positive effect compared to fixed effects least square method. A 1% increase in healthcare expenditure per capital increases life expectancy at birth by 0.112% or equivalent of 1.658 life years but this is not significant. In OECD countries, first stage results at significant at 5% level and FFS and PBP decreases healthcare expenditure by 0.0389%. Healthcare expense per capita increases life expectancy at birth by 0.088% and is significant at 10% level. The Durbin, Wu-Haussmann test of exogeniety reveals rejection of the null of exogeniety of regressors at 10% level, across all the three sample. The supports the use of an IV approach to OLS for unbiased estimation. However, the proposed instruments of FFS and PBP do not pass the joint F test of relevance (all countries sample: F value 0.346; OECD countries: F value 6.46; Eastern/Central Europe and Central Asia: F value 3.36)

Table 5: Causal effects of hospital payment systems on life expectancy at birth (Instruments: FFS and PBP)

	All countries		Central/Eastern Europe/Central Asia		OECD	
	FE-LS	IV Estimates	FE-LS	IV estimates	FE-LS	IV estimates
FFS+PBP (First stage FFS)		0.01338		0.087		-0.0389
		[0.0328]		[0.0446]**		[0.0140]***
FFS+PBP (First stage PBP)		0.0279		0.0594		0.01567
		[0.0372]		[0.0767]		[0.0315]
Second stage						
Ln Healthcare expenditure per capita	0.00683	0.112	0.01049	0.0746	0.0104	0.0881
	[0.00537]	[0.1330]	[0.0080]	[0.497]	[0.0118]	[0.0546]*
Ln GDP per capita (exclude healthcare expenditure)	-0.01623	-0.0295	-0.00837	0.00583	-0.00875	-0.045
	[0.0078]**	[0.0263]	[0.0131]	[0.0161]	[0.0095]	[0.0289]

*significant at 0.10 significance level **significant at 0.05 significance level ***significant at 0.01 significance level

Reflecting on the chosen FFS and PBP hospital payment system instrument, we may postulate various reasons why it may not work effectively. Classification of hospital payment is not necessarily a true reflection of what may be ongoing in a country at a point in time. Wubulihasimu et al., (2015) and Moreno-Serra and Wagstaff (2010) offered caveats in their classification as most countries operate on mixed systems at different healthcare touchpoints. Moreover, not all hospital payment systems reforms were implemented at the same time across a country (Wubulihasimu et al., 2015; Moreno-Serra and Wagstaff, 2010). For robustness and sensitivity checks, we estimated the models with the alternative hospital classification system presented in both Wubulihasimu et al., (2015) and Moreno-Serra and Wagstaff, (2010) papers. This findings are presented in the Section 4.2.

A more pertinent issue is the potential existence of endogeniety. FFS and PBP hospital payment systems may lead to better quality care and lower mortality rates (Wubulihasimu et al., 2015). Thus, the proposed instrument may be correlated with health outcome of life expectancy at birth. FFS and PBP hospital payment systems may also correlate with other potential omitted variables in error term like lifestyle and types of diseases which may affect both life expectancy at birth and choice of hospital payment system in a country in controlling for healthcare financing. However, we are not able to fully test if the IV of hospital payment system is valid and not correlated to the error term, beyond reasoning for the need of an IV approach with the Durbin, Wu-Haussmann test of exogeniety of regressors.

4.2 Robustness and sensitivity check

One of the challenges of this study is the choice of classification of hospital payment schemes (Wubulihasimu et al., 2015; Moreno-Serra and Wagstaff, 2010). For robustness analysis, we re-estimated the model using alternative classification of payment schemes following the classifications used by Wubulihasimu et al., (2015) and Moreno-Serra and Wagstaff, (2010) in Appendix 3.

Table 6 shows the fixed effects estimation results with alternative payment schemes classification. This new classification yields similar results as the original classification in the effect of healthcare expenditure per capita on life expectancy at birth (equation 1). The results remain insignificant.

Table 6: Estimated effects of healthcare expenditure per capita on life expectancy at birth with alternative hospital payment systems classification

	All countries N =541	Central/Eastern Europe/Central Asia N= 253	OECD N=288
Dependent variables			
Healthcare expenditure per capita	0.0068335	0.01049	0.0104
	[0.00537]	[0.0080]	[0.01181]
GDP per capital (exclude healthcare expenditure)	-0.01623	-0.00837	-0.00875
	[0.0078]**	[0.01312]	[0.00950]
Share of population above 65 years old	-0.001450	-0.05823	0.00025
	[0.00140]	[0.00425]	[0.00121]

*significant at 0.10 significance level **significant at 0.05 significance level ***significant at 0.01 significance level

Table 7 shows the estimates of impact of FFS and PBP hospital payment systems on healthcare expenditure per capita (equations 2 and 3) using the alternative hospital payment classification system. All the signs off FFS and PBP effects on healthcare expenditure per capita remains similar as using the original classification. In the new classification for Central /Eastern Europe and Central Asia, FFS and PBP decreases its impact on healthcare expenditure per capita compared to Fixed Budget, but is significant at 5% level only for FFS. For OECD countries, the alternative classification led to bigger effects of FFS and PBP on healthcare expenditure compared to Fixed Budget system and is significant for FFS at 1% level.

Table 7: Estimated effects of hospital payment systems FFS and PBP on healthcare expenditure per capita. Comparison with alternative hospital payment systems classification estimates

	All countries n=560		Central/Eastern Europe/Central Asia n= 270		OECD n=290	
	Original classification	Alternative classification	Original classification	Alternative classification	Original classification	Alternative classification
FFS	0.0108	0.0007	0.08651	0.06636	-0.0392	-0.04137
	[0.02968]	[0.0296]	[0.0306]***	[0.0302]**	[0.0127]***	[0.01135]***
PBP	0.0299	0.0081	0.0727	0.0243	0.0163	0.0316
	[0.0333]	[0.0307]	[0.0545]	[0.0.04685]	[0.0289]	[0.0282]

*significant at 0.10 significance level **significant at 0.05 significance level ***significant at 0.01 significance level

We present the results of the IV regression using FFS +PBP hospital payment system as the instrument (equation 2 and 3) in Table 8 for health outcome of life expectancy at birth using alternative hospital payment system. The first column shows results of the original classification system and second column the new IV estimates with alternative classification. There is a significant effect at 5% level of a 1 % increase in healthcare expenditure leading to increase in life expectancy at birth by 0.08119%, equivalence of 0.9653 life years for OECD countries. Beyond that, the new IV estimates shows a much bigger impact of healthcare expenditure on life expectancy at birth, with 1 % increase in healthcare expenditure per capita leading to an increase of 0.5132% increase in life expectancy at birth for all countries sample. This is equivalent to an increase of 7.599 life years given the within variation of healthcare expenditure in our sample over period of 1990 – 2004. However, this is not significant. There is also a change in sign in effect of healthcare expenditure per capita on life expectancy at birth for Eastern/Central Europe and Central Asia countries, where increases in healthcare expenditure per capita decreases life expectancy at birth. With the alternative hospital classification system, the chosen FFS and PBP hospital payment system IV passes the F test of reliability only for OECD countries (F statistic 11.85). The proposed instrument of FFS and PBP also passes the Durbin Wu Haussmann test of exogeniety for all country sample, and OECD countries.

Table 8: IV regression results with alternative hospital payment system classification (Instruments: FFS + PBP)

	All countries		Central/Eastern Europe/Central Asia		OECD	
	Original classification	Alternative classification	Original classification	Alternative classification	Original classification	Alternative classification
FFS+PBP (First stage FFS)	0.01338	0.00275	0.087	0.0625	-0.0389	-0.0409
	[0.0328]	[0.0328]	[0.0446]**	[0.0472]	[0.0140]***	[0.0126]***
FFS+PBP (First stage PBP)	0.0279	0.00753	0.0594	0.00344	0.01567	0.0312
	[0.0372]	[0.0343]	[0.0767]	[0.0667]	[0.0315]	[0.0308]
Second stage						
Ln Healthcare expenditure per capita	0.112	0.5132	0.0746	-0.02154	0.0881	0.08119
	[0.1330]	[2.0288]	[0.497]	[0.0663]	[0.0546]	[0.0389]**
Ln GDP per capita (exclude healthcare expenditure)	-0.0295	-0.0847	0.00583	-0.01223	-0.045	-0.0418
	[0.0263]	[0.0276]	[0.0161]	[0.0145]	[0.0289]	[0.0211]**

*significant at 0.10 significance level **significant at 0.05 significance level ***significant at 0.01 significance level

In summary, the main results of the causal estimation of healthcare expenditure per capita on life expectancy at birth shows that the IV of FFS and PBP hospital payment system for healthcare expenditure is relevant for OECD countries estimation. An increase in healthcare expenditure leads to significant increase in life expectancy at birth. However, we do not have sufficient evidence in this study to say the same for the all country and Eastern/Central Europe and Central Asia sample.

Section 5: Discussions and limitations

This study was initiated to estimate the causal impact of healthcare expenditure on life expectancy at birth. Instruments of FFS and PBP hospital payment systems are used for healthcare expenditure, to utilize only this variation to estimate causal impact on life expectancy at birth. Estimation was conducted controlling for population structure, GDP excluding healthcare expenditure, country level heterogeneity and a time trend dummies variable to capture factors that affect all countries like technological innovation. We hypothesized FFS and PBP hospital payment schemes to increase healthcare expenditure per capita compared to fixed budgets. Secondly, we expected additional healthcare expenses caused by hospital payment schemes variation to increase life expectancy at birth.

Overall, our strongest results are findings of a significant strong association of a positive impact healthcare expenditure on life expectancy at birth for OECD countries. 1 % increase in healthcare expenditure on increases life expectancy at birth by 0.08119%, an equivalence of 0.9653 life years for OECD countries, using FFS and PBP as instruments in OECD countries for the alternative hospital classification system. Similarly, life expectancy at birth increases by 0.088% for OECD countries, using the original hospital classification system. Beyond this, our results have not been able to offer a strong association or causal impact estimation of healthcare expenditure per capital on life expectancy at birth in both hospital classification systems. Although insignificant, the results generally show a positive association of healthcare expenditure on life expectancy at birth in all samples, except under the alternative hospital classification system for Eastern/Central Europe and Central Asia. Findings from Durbin Wu Haussmann test of exogeniety promote the use of an IV approach over least squared estimation for unbiased findings. However, only the IV regression with OECD countries alternative hospital classification system passes the F test of joint relevance. This raises discussion on the validity of these proposed FFS and PBP instruments.

Moreover, we were only able to weakly support our hypothesis that FFS increases healthcare expenditure as it is only significant for sample of Central/Eastern Europe and Central Asia. Moreover, FFS significantly decreases healthcare expenditure per capita in OECD countries compared to fixed budget. This is potentially attributed to the rise of HMOs in these OECD to manage increased cost driven by supply side induced demand from the FFS incentive system. PBP hospital payment systems also has positive impact on healthcare expenditure per capita for all samples. However, none of these are significant. This finding of negative impact of FFS hospital payment system on healthcare expenditure in the OECD countries is contrary to Wubulihasimu et al., (2015) who established a positive effect. This may be due to the difference in the time period included in this study of only 1990-2004 versus their paper which estimated a similar model using longer time span from years 1980 to 2009, potentially capturing more changes and impact of FFS on healthcare expenses per capita.

Although we have not been able to find strong support for all our hypothesis and in the causal estimation of healthcare expenditure using the original hospital payment classification system, this study has merits in attempting to put together the two sets of hospital payment systems developed by Wubulihasimu et al., (2015) and Moreno-Serra and Wagstaff, (2010). Thereby, allowing for exploration of FFS and PBP hospital payment systems as an IV for causal estimation of healthcare expenditure on life expectancy at birth. It helped us examine this question for a wider set of 48 OECD and Central/Eastern Europe and Central Asia countries. Another strength is the robustness check using the alternative hospital payment classification system which gave strong positive association of healthcare expenditure per capita on life expectancy at birth for OECD countries.

There are however several limitations to this study, which to some extent, may have contributed to the weak findings of our hypothesis. The primary limitation involves the choice, effectiveness and validity of the proposed FFS and PBP hospital payment system as instruments for healthcare expenditure per capita. First, the chosen instrument maybe subjected to endogeneity issues. Wubulihasimu et al., (2015) found FFS and PBP to have negative effects on health outcomes like infant mortality and amendable mortality, signaling potential correlation of, the proposed instrument with health outcome of life expectancy at birth. Additionally, FFS and PBP hospital payment system may also correlate with other potential omitted variables in the error term like self assessed health, lifestyle adoption and types of diseases. Second, hospital payment systems represents only the supply side of healthcare financing. Using hospital payment systems to tap into the variation in healthcare financing as a proxy to healthcare expenditure captures only the supply side of healthcare financing. This study could have also explored the possibility of including demand side of healthcare financing such as taxation, private payment and social health insurance as an additional instruments. Third, the classification of hospital payment system used in this study has been adopted from Wubulihasimu et al., (2015) and Moreno-Serra and Wagstaff (2010). The authors have pointed out various challenges of developing a perfect classification as often multiple systems co-exist at any point in time for a country. Moreover, change in hospital payment system tend to be rolled out across different states at different time. This, to some extent may be affected the reliability of using FFS and PBP hospital payment system as instruments for healthcare expenditure

Another limitation is the potential reversed causality of life expectancy at birth affecting choice of hospital payment systems and healthcare expenditure per capita, as well as delayed effects of hospital payment reforms on health outcomes (Wubulihasimu et al., 2015). A decrease in life expectancy trigger changes in hospital payment systems, such as from fixed budget to FFS to promote increase quality of healthcare or decrease waiting time. This would have led to reverse causality deeming the instruments of FFS and PBP hospital payment systems to be endogenous. Part of this possibility could have been addressed by using first lags of the FFS and PBP dummies as in Wubulihasimu et al., (2015). However, this option was not conducted in this study due to the small number of years 1990 to 2004 and small within variation in hospital payment systems in this period. Future research may consider implementing an instrumental variable approach incorporating the reverse causality as in the model specification used by Moreno-Serra and Smith (2015).

Overall, current proposed FFS and PBP hospital payment systems have been demonstrated to be weak instruments for causal impact estimation of healthcare expenditure on life expectancy at birth. Striving towards the goal of exogeniety of the instrument, research may want to explore other less conventional instruments that are driven by a person’s psychology and self-concept, independent of the healthcare financing macro system and environment, thereby subjecting it to lesser potential endogeniety issues. An interesting case in point could be the number of atheists in a country. We may postulate a potential positive relationship between healthcare expenditure and the number of non-religious people, assuming they may want stronger control of their lives and have a stronger relationship with healthcare. Such attempts may reveal new perspective to the debate of effectiveness of healthcare expenditure on health outcomes.

Furthermore, the choice of life expectancy at birth as the health outcome variable, whilst having the advantage of being more easily accessible in data across countries and time, does not capture morbidity and quality of life improvement. Having characteristics of a general variable also makes it more susceptible to endogeniety issues. Future research should consider estimating with different health outcomes like amendable mortality and infant mortality. Here, we did not consider it due to data availability issues.

One other limitation is the selection and use of fixed effects least square estimation in this study. Initial data has shown small within variation. However, due to the restrictive nature of Random effects in assuming no correlation between the fixed individual heterogeneity and independent variables, as well as best practices from previous research Wubulihasimu et al., (2015) and Moreno-Serra and Wagstaff (2010), we adopted the fixed effect model for this study. Perhaps, future research can consider exploring the use of Correlated Random Effects estimator which models the correlation between fixed individual heterogeneity and independent X variables (Wooldridge, 2014), which is less restrictive than conventional Random effects estimator.

Finally, the overall sample is small in number of observations, with substantial missing values. To account for more country estimation of Central/Eastern Europe and Central Asia, we limit the study to time period of 1990-2004, with 150 missing observations of healthcare expenditure per capita in Central/Eastern Europe and Central Asia.

Concluding, estimating casual impact of healthcare expense on health outcomes is a pertinent and current issue with rising healthcare expenses burden. Our findings has shown a positive association of healthcare expenditure on life expectancy at birth especially for OECD countries. Our results have also shown GDP per capita excluding healthcare expenditure to have a negative impact on life expectancy at birth. This may loosely attribute the success in increased life expectancy at birth to be due to direct healthcare spending, rather than spending on other public infrastructure like education, transportation which also influences quality of life and thereby life expectancy at birth.

If healthcare expenditure are associated with people living longer, this has impact on policies like increased burden on public finance, questions on pension's availability and sustainability, as well as funding of social insurance. One aspect to consider is the management of healthcare cost. In this study, FFS hospital payment systems are also shown to decrease healthcare expenditure in OECD countries, versus increasing them in Eastern/Central Europe and Central Asia countries. This can partly be explained by the rise of HMOs in OECD countries in managing cost and reimbursement of FFS systems. More research can be conducted to establish the impact of HMO on healthcare expenditure control in various payment systems. If HMO is an effective tool for managing cost, this may help relieve the burden on pensions systems and social insurance.

More importantly, if people are living longer, especially amongst the elderly, we would like to encourage changing societal perceptions of this elderly segment from being a burden to society due to healthcare cost, to them still being integrated and bringing both economic and non-economic value to society. Policies and institutions can be enacted to renew the lives of the elderly. Through understanding their needs, challenges, their assets, skills, experience, dreams and wish to still serve - to create different avenues, facilitating and enabling the elderly segment to contribute to society in what they are good at, passionate about, to feel full again - where doing something re-energizes the individual. As such, the increase in life expectancy with increased healthcare expenditure serves a purpose beyond escaping from the fear of dying, to one that generates the fullness of life, value to humanity, acceptance and readiness. Where, solidarity goes beyond being a security net compensating for individual weakness of the human spirit, to one which bears more value and vibrancy to society.

Bibliography:

Barker (1995) HMOs and Fee-For-Service Health Care Expenditures: Evidence from Medicare, NBER Working Paper No. 5360

Barnum, H., Kutzin, J., & Saxenian, H. (1995). Incentives and provider payment methods. *The International journal of health planning and management*, *10*(1), 23-45.

Busse, R., Schreyögg, J., & Smith, P. C. (2006). Editorial: hospital case payment systems in Europe. *Health care management science*, *9*(3), 211-213.

Cochrane, A. L., St Leger, A. S., & Moore, F. (1978). Health service input and mortality output in developed countries. *Journal of epidemiology and community health*, *32*(3), 200-205.

Crémieux, P. Y., Ouellette, P., & Pilon, C. (1999). Health care spending as determinants of health outcomes. *Health Economics*, *8*(7), 627-639.

Cutler, D. M. (1993). *The incidence of adverse medical outcomes under prospective payments* (No. w4300). National Bureau of Economic Research.

Cutler, D. M. (2002). Equality, efficiency, and market fundamentals: the dynamics of international medical-care reform. *Journal of economic literature*,*40*(3), 881-906.

Cylus, J., & Irwin, R. (2010). The challenges of hospital payment systems.*Euro Observer*, *12*(3), 1-3.

Dafny, L. S. (2003). *How do hospitals respond to price changes?* (No. w9972). National Bureau of Economic Research.

Davis, C. K., & Rhodes, D. J. (1988). The impact of DRGs on the cost and quality of health care in the United States. *Health Policy*, *9*(2), 117-131

Dismuke, C. E., & Guimaraes, P. (2002). Has the caveat of case-mix based payment influenced the quality of inpatient hospital care in Portugal?. *Applied Economics*, *34*(10), 1301-1307.

Ellis, R. P., & Miller, M. M. (2007). Provider payment methods and incentives.

Ellis, R. P., & McGuire, T. G. (1986). Provider behavior under prospective reimbursement: Cost sharing and supply. *Journal of health economics*, *5*(2), 129-151.

Goldstein, J. R., & Wachter, K. W. (2006). Relationships between period and cohort life expectancy: Gaps and lags. *Population Studies*, *60*(3), 257-269.

Gravelle, H. S. E., & Backhouse, M. E. (1987). International cross-section analysis of the determination of mortality. *Social Science & Medicine*, *25*(5), 427-441

Heijink, R., Koolman, X., & Westert, G. P. (2013). Spending more money, saving more lives? The relationship between avoidable mortality and healthcare spending in 14 countries. *The European Journal of Health Economics*, *14*(3), 527-538.

Hitiris, T., & Posnett, J. (1992). The determinants and effects of health expenditure in developed countries. *Journal of health economics*, *11*(2), 173-181.

Hodgkin, D., & McGuire, T. G. (1994). Payment levels and hospital response to prospective payment. *Journal of health economics*, *13*(1), 1-29.

Gerdtham, U. G., & Jönsson, B. (2000). International comparisons of health expenditure: theory, data and econometric analysis. *Handbook of health economics*, *1*, 11-53.

Kroneman, M., & Nagy, J. (2001). Introducing DRG-based financing in Hungary: a study into the relationship between supply of hospital beds and use of these beds under changing institutional circumstances. *Health Policy*,*55*(1), 19-36.

Kwon, S. (2003). Payment system reform for health care providers in Korea.*Health Policy and Planning*, *18*(1), 84-92.

Jegers, M., Kesteloot, K., De Graeve, D., & Gilles, W. (2002). A typology for provider payment systems in health care. *Health policy*, *60*(3), 255-273.

Martin, S., Rice, N., & Smith, P. C. (2008). Does health care spending improve health outcomes? Evidence from English programme budgeting data. *Journal of health economics*, *27*(4), 826-842.

Moreno-Serra, R., & Smith, P. C. (2015). Broader health coverage is good for the nation's health: evidence from country level panel data. *Journal of the Royal Statistical Society: Series A (Statistics in Society)*, *178*(1), 101-124.

Moreno-Serra, R., & Wagstaff, A. (2010). System-wide impacts of hospital payment reforms: evidence from Central and Eastern Europe and Central Asia. *Journal of Health Economics*, *29*(4), 585-602.

Murray, C. J., Salomon, J. A., & Mathers, C. (2000). A critical examination of summary measures of population health. *Bulletin of the World Health Organization*, *78*(8), 981-994.

Nixon, J., & Ulmann, P. (2006). The relationship between health care expenditure and health outcomes. *The European Journal of Health Economics*, *7*(1), 7-18.

Nolte, E., & McKee, M. (2004). *Does health care save lives? Avoidable mortality revisited* (p. 139). The Nuffield Trust.

Or, Z. (2001). Exploring the effects of health care on mortality across OECD countries.

Shmueli, A., Stam, P., Wasem, J., & Trottmann, M. (2015). Managed care in four managed competition OECD health systems. *Health Policy*, *119*(7), 860-873.

van Baal, P., Obulqasim, P., Brouwer, W., Nusselder, W., & Mackenbach, J. (2013). *The influence of health care spending on life expectancy* (No. 35).

Wagstaff, A. (2009). Social health insurance vs. tax-financed health systems-evidence from the OECD. World Bank Policy Research Working Paper, (4821).

Wooldridge, J. M. (2014). *Introduction to Econometrics: Europe, Middle East and Africa Edition*.

Wubulihasimu, P., Brouwer, W., & Baal, P. (2015). The impact of hospital payment schemes on healthcare and mortality: evidence from hospital payment reforms in OECD countries. *Health economics*.

Young, F. W. (2001). An explanation of the persistent doctor-mortality association. *Journal of Epidemiology and Community Health*, *55*(2), 80-84.

Appendix

Appendix 1: Missing values

	Healthcare expenditure per capita	Life expectancy at birth	Hospital payment system classification	GDP per capita
Total	N =150	N = 39	N=13	N=37
East Europe/ Central Asia 1990 - 1994	N = 140	-	-	-
Albania 1991	-	N =1	-	-
Armenia 2004	-	N=1	-	-
Bosnia and Herzegovina 1990-1993	-	-	-	N = 4
Belarus 2001-2004	-	-	N =4	-
Bosnia and Herzegovina 1992-1996	-	N =5	N = 5	-
Bosnia and Herzegovina 1997-2004	-	N =8	-	-
Macedonia 1990-2004	-	N=14	-	-
Croatia 1990-1994	-	-	-	N=5
Czech Republic 1997-2000	-	-	N =4	-
Estonia 1990-1994	-	-	-	N=5
Georgia 1993	-	N=1	-	-
Lithuania 1990 -1994	-	-	-	N=5
Latvia 1990-1994	-	-	-	N=5
Slovenia 1991-1994	-	-	-	N=4
Slovak Republic 1990-1991	-	-	-	N=2
Serbia and Montenegro 1990-1997	-	-	-	N=5
Turkmenistan 1999-2004	-	N=6	-	-
Germany 1991	N=1	-	-	-
Luxemburg 1990-1998	N=9	-	-	-
Canada 1993	-	N=1	-	-
Italy 2004	-	N=1	-	-

Appendix 2: Correlation of hospital payment systems with healthcare expenditure per capita

Correlation of FFS/PBP/AB on ln Healthcare expenditure per capita			
	Ln Healthcare expenses per capita		
	All countries	Central/Eastern Europe/Central Asia	OECD
Activity Based	0.115	0.422	0.031
FFS	0.0284	0.3125	-0.1878
PBP	0.1054	0.205	0.1732

Appendix 3: Alternative classification of hospital payment system

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Albania	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
Armenia	FB	FB	FB	FB	FB	FB	FB	FB	PBP	PBP	PBP	PBP	PBP	PBP	PBP
Azerbaijan	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
Belarus	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	.	.	.	.
Bosnia and Heregovina	FB	FB	.	.	.	.	.	FB	FB	FB	FB	FB	FB	FB	FB
Bulgaria	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	PBP
Croatia	FB	FB	FB	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	PBP	PBP	PBP
Czech Republic	FB	FB	FB	FFS	FFS	FFS	FFS	.	.	.	.	PBP	PBP	PBP	PBP
Estonia	FB	FB	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS
Georgia	FB	FB	FB	FB	FB	FB	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP
Hungary	FB	FB	FB	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP
Kazakhstan	FB	FB	FB	FB	FB	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP
KyrgyzR	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	PBP	PBP	PBP	PBP
Latvia	FB	FB	FB	FB	FFS	FFS	FFS	FFS	PBP	PBP	PBP	PBP	PBP	PBP	PBP
Lithuania	FB	FB	FB	FB	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP
Macedonia	FB	FFS	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
Moldova	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
Poland	FB	FB	FB	FB	FB	FB	FB	FB	FB	FFS	FFS	FFS	FFS	PBP	PBP
Romania	FB	FB	FB	FB	FB	FB	FB	FB	FB	FFS	FFS	FFS	FFS	FFS	FFS
Russianfed	FB	FB	FB	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP
SerbiaMontenegro	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
slovakR	FB	FB	FB	FFS	FFS	FFS	FFS	FFS	FFS	FB	FB	FB	PBP	PBP	PBP
Slovenia	FB	FB	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	PBP	PBP	PBP	PBP	PBP
Taijkistan	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
Turkey	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
Turkmenistan	FB	FB	FB	FB	FB	FB	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP
Ukraine	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
Uzbekistan	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
Australia	FB	FB	FB	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP
Austria	FB	FB	FB	FB	FB	FB	FB	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP
Belgium	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	PBP	PBP	PBP
Canada	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
Denmark	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	PBP
Finland	FB	FB	FB	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	PBP	PBP	PBP	PBP
France	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	PBP
Germany	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	PBP
Greece	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS	FFS
Iceland	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
Ireland	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	PBP	PBP	PBP	PBP
Italy	FB	FB	FB	FB	FB	FB	FB	FB	FB	PBP	PBP	PBP	PBP	PBP	PBP
Luxemburg	FFS	FFS	FFS	FFS	FFS	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
Netherlands	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FFS	FFS	FFS	FFS
Norway	FB	FB	FB	FB	FB	FB	FB	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP
Portugal	FB	FB	FB	FB	FB	FB	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP	PBP
Spain	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB
Sweden	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	PBP	PBP	PBP
Switzerland	FFS	FFS	FFS	FFS	FFS	FFS	FB	FB	FB	FB	FB	FB	FB	PBP	PBP
UK	FFS	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB	FB