Is an ounce of prevention worth a pound of cure? A cross-sectional study of the impact of the English public health grant on mortality and morbidity

Appendices

Appendix A1

Is public health expenditure solely preventative?

One rudimentary guide to the volume of preventative expenditure by CCGs is provided by the programme budgeting data set for 2013/14. This reports a total spend of £411m in the 'Healthy Individuals' programme of which £151m is for 'prescribing in primary care' and £190m is for 'community and integrated care'.[1] In principle we could add this expenditure (£411m) to that from the public health grant (£2,500m) to obtain an overall measure of public health spend. However, as the precise set of activities covered by this CCG 'Healthy Individuals' expenditure is unclear and there are always issues about how consistently different CCGs allocate activity to different programme budget categories, we prefer to focus on the public health grant as our measure of public health expenditure. We include the 'Healthy Individuals' spend as part of the total measure of healthcare (treatment) expenditure. Our estimates of the impact of the public health grant and CCG expenditure will largely reflect 'prevention' and 'treatment' effects respectively, but we acknowledge that there will be relatively small elements of treatment expenditure in the prevention measure, and relatively small elements of prevention expenditure in the treatment measure.

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Appendix A2

On the use of the market forces factor (MFF) as an instrument for public health expenditure

The local input price index (MFF), which will reflect characteristics of the local (health) economy, may be correlated with unmeasured determinants of mortality. However, we have over a dozen potential socio-economic covariates (including the Index of Multiple Deprivation) in the baseline mortality equation and hence it is difficult to imagine what effect the input price index would detect that our covariates do not. Of course, if a locality gets a larger budget to compensate for the higher cost of supplying healthcare, as happens with the local price index, and this adjustment exactly compensates for additional costs, then there is no reason why this additional spending should improve health because it does not correspond to an increase in real spending. In reality, of course, the cost adjustment will not be perfect. Some local authorities will be over compensated and hence receive 'too much' funding; others will be under compensated and receive 'too small' a budget. This imperfect adjustment for local conditions provides the link between this instrument, expenditure and mortality. The same argument applies to the use of the age index as an instrument for healthcare expenditure discussed later.

Appendix A3

Estimation strategy with the inclusion of healthcare expenditure

Initially the health outcome equation (equation 1) is estimated using the strategy described in section 2.2 with public health as the sole health expenditure variable. We then re-estimate equation 1 – using the same strategy – but this time including healthcare expenditure as an additional endogenous regressor. This variable is instrumented in a similar way to public health. However, the identification of the relevant funding rule variables is slightly complicated because of the changes imposed by the Health and Social Care Act 2012. Usually funding formulae are updated every year but the impending abolition of PCTs meant that the weighted capitation formula was frozen for 2012-13, with all PCTs receiving the same (3%) growth rate over their 2011/12 allocations. As CCG responsibilities in 2013/14 differed from those for PCTs (eg they lost responsibility for public health, specialised services, and primary care), there was a baseline exercise in 2012 that stripped out actual expenditure on these components and, for 2013-14, each CCG was given an uplift of 2.3% on these 2012 baselines.[2]

The implication of these developments for this study is that the best funding rule variables we can identify for CCG healthcare expenditure in 2013/14 are drawn from the 2011/12 allocations for PCTs, appropriately mapped to the new (CCG) geography. These allocations reflect three separate funding formulae (one for Hospital and Community Services (HCHS), one for prescribing, and one for primary care), and we select three funding rule variables employed in these formulae which we believe are uncorrelated with mortality. In particular, our funding rule variables for healthcare expenditure are: (i) the DFT for the total allocation to PCTs for 2011/12; (ii) the MFF for the HCHS component of the total allocation; and (iii) the age index from the prescribing cost component of the total allocation. The DFT variable is available from the Department of Health's website at https://www.networks.nhs.uk/nhsnetworks/health-investment-network/news/2012-13-programme-budgeting-data-is-nowavailable (accessed 22 July 2020), and the MFF and prescribing cost age indices are available from the exposition books for the 2011/12 allocations at https://www.gov.uk/government/publications/exposition-book-2011-2012 (accessed 22 July 2020).

A recent study provided no explicit arguments in support of these instruments for healthcare expenditure but this omission is easily remedied.[3] First, our measure of mortality and the prescribing cost age index instrument are both standardised for age, and so the age index is unlikely to be correlated with the error from equation (1). Second, and as already noted when discussing the instruments for public health expenditure, the local input price index will reflect characteristics of

the local (health) economy and these might be correlated with unmeasured determinants of mortality. However, we have over a dozen potential socio-economic covariates in the baseline mortality equation and hence it is difficult to imagine what effect the MFF would detect that our covariates do not. Third, the DFT variable for healthcare allocations will reflect the various funding formulae and 'pace of change' policies implemented under several governments of various political persuasions over the past thirty years. The 'pace of change' and the consequent DFT are policy choices but it is not obvious that the latter will be endogenous with respect to mortality; and, as noted for the instruments for public health expenditure, any correlation between our instruments and the error term in equation (1) is likely to be detected by the Hansen-Sargan test.

Appendix A4

Extended presentation of results

With the public health grant as the only expenditure variable

Estimation of the health outcome equation (equation 1) with public health as the sole expenditure variable generates the result shown in column 1 of table A1. The corresponding first-stage result is in column 1 of table A2. Application of the backward selection process generates the more parsimonious specification shown in column 2 of table A1. Public health expenditure has the anticipated negative association with mortality but this specification fails the reset test and the instrument set is invalid (the Hansen-Sargan test statistic pvalue<0.100). The addition of IMD 2010 squared to the specification resolves the reset test but not the instrument validity issue (column 3). The result in column 4 omits that instrument (the MFF index) which is the most significant when added as a control to the second-stage equation. The significant positive coefficient (0.252) on the 'white ethnicity' variable might reflect a lifestyle effect but, in the interests of clarity, we re-estimate without this variable and obtain the result shown in column 5. The coefficient on the 'permanently sick' variable increases considerably (from 0.265 to 0.475) and the coefficient on the 'working in agriculture' variable is no longer significant. Re-estimation without the latter variable generates our preferred specification shown in column 6. In this, public health expenditure has a modest but statistically significant negative association with mortality, expenditure is endogenous, there is no evidence of weak instruments (the Kleibergen-Paap F statistic exceeds the rule-of-thumb threshold value (=10)), and the specification passes the reset test.

Table A1 Derivation of preferred specification for public health expenditure, second-stage results, 2013/14

VARIABLES	(1) All causes 2013/14 PH spend SYLLR 2013/14/15 outcome model instrument PH spend weighted IV second stage full specification	(2) All causes 2013/14 PH spend SYLLR 2013/14/15 outcome model instrument PH spend weighted IV second stage new derivation	(3) All causes 2013/14 PH spend SYLLR 2013/14/15 outcome model instrument PH spend weighted IV second stage new derivation revised1	(4) All causes 2013/14 PH spend SYLLR 2013/14/15 outcome model instrument PH spend weighted IV second stage new derivation revised2	(5) All causes 2013/14 PH spend SYLLR 2013/14/15 outcome model instrument PH spend weighted IV second stage new derivation revised2 SA_1	(6) All causes 2013/14 PH spend SYLLR 2013/14/15 outcome model instrument PH spend weighted IV second stage new derivation revised2 SA_2
Public health spend per person	-0.084**	-0.122***	-0.108**	-0.119***	-0.116**	-0.115**
	[0.041]	[0.046]	[0.043]	[0.043]	[0.047]	[0.048]
IMD 2010	0.203***	0.152**	-0.271*	-0.374**	-0.509***	-0.505***
	[0.075]	[0.063]	[0.141]	[0.146]	[0.163]	[0.157]
Proportion of all residents born outside the EU	-0.016					
	[0.018]					
Proportion of population in white ethnic group	0.246***	0.261***	0.249***	0.252***		
	[0.060]	[0.039]	[0.038]	[0.038]		
Proportion of population providing unpaid care	-0.439***	-0.346***	-0.271***	-0.235***	-0.235***	-0.231**
	[0.167]	[0.088]	[0.083]	[0.084]	[0.090]	[0.091]
Proportion of population aged 16-74 with no qualifications	-0.034					
	[0.112]					
Proportion of households without a car	-0.062					
	[0.072]					
Proportion of households that are owner occupied	0.129*					
	[0.071]					
Proportion of households that are one pensioner households	-0.082					
	[0.084]					
Lone parent households with dependent children	0.056					
	[0.060]					
Proportion of population aged 16-74 that are permanently sick	0.315***	0.319***	0.284***	0.265***	0.475***	0.475***
	[0.070]	[0.077]	[0.071]	[0.072]	[0.067]	[0.068]
Proportion of those aged 16-74 that are long-term unemployed	0.039					
	[0.057]					
Proportion of those aged 16-74 working agriculture	-0.015	-0.025***	-0.020***	-0.016**	0.001	
	[0.010]	[0.007]	[0.007]	[0.007]	[0.007]	
Proportion of those aged 16-74 in professional occupations	-0.201***	-0.268***	-0.243***	-0.230***	-0.204***	-0.205***
	[0.077]	[0.044]	[0.046]	[0.047]	[0.050]	[0.049]

IMD 2010 Squared			0.078***	0.100***	0.093***	0.092***
			[0.026]	[0.027]	[0.029]	[0.028]
Constant	5.532***	5.895***	6.514***	6.710***	7.941***	7.936***
	[0.649]	[0.349]	[0.393]	[0.402]	[0.397]	[0.402]
Observations	151	151	151	151	151	151
Endogeneity test statistic	11.369	10.449	8.572	15.109	13.881	10.579
Endogeneity p-value	0.001	0.001	0.003	0.000	0.000	0.001
Hansen-Sargan test statistic	14.750	10.957	14.408			
Hansen-Sargan p-value	0.000	0.001	0.000			
Kleibergen-Paap LM test statistic	26.821	34.909	35.502	34.884	34.868	32.762
Kleibergen-Paap p-value	0.000	0.000	0.000	0.000	0.000	0.000
Kleibergen-Paap F statistic	69.320	88.578	99.555	192.280	185.421	120.521
Pesaran-Taylor reset statistic	10.116	6.248	0.599	0.469	2.422	2.456
Pesaran-Taylor p-value	0.001	0.012	0.439	0.493	0.120	0.117

Robust standard errors in brackets

*** p<0.01, ** p<0.05, * p<0.1

Table A2 First-stage regression results for derivation of preferred specification for public health expenditure, 2013/14

	(1)	(2)	(3)	(4)	(5)	(6)
	All causes	All causes	All causes	All causes	All causes	All causes
	2013/14 PH spend	2013/14 PH spend	2013/14 PH spend	2013/14 PH spend	2013/14 PH spend	2013/14 PH spend
	SYLLR 2013/14/15	SYLLR 2013/14/15	SYLLR 2013/14/15	SYLLR 2013/14/15	SYLLR 2013/14/15	SYLLR 2013/14/15
	outcome model	outcome model	outcome model	outcome model	outcome model	outcome model
	first-stage	first-stage	first-stage	first-stage	first-stage	first-stage
	weighted	weighted	weighted	weighted	weighted	weighted
	OLS	OLS	OLS	OLS	OLS	OLS
	full specification	new derivation	new derivation revised1	new derivation revised2	new derivation revised2 SA_1	new derivation revised2 SA_2
VARIABLES						
DFT index_Public health_1314	0.729***	0.747***	0.762***	0.759***	0.759***	0.739***
	[0.062]	[0.056]	[0.054]	[0.055]	[0.056]	[0.067]
MFF Index_Public health_1314	-0.655*	-0.559	-0.565			
	[0.350]	[0.348]	[0.352]			
IMD 2010	0.122	0.139	-0.590	-0.548	-0.599*	-0.931**
	[0.137]	[0.113]	[0.388]	[0.357]	[0.357]	[0.388]
Proportion of all residents born outside the EU	0.031					
	[0.050]					
Proportion of population in white ethnic group	0.309*	0.020	0.028	0.095		
	[0.178]	[0.083]	[0.080]	[0.071]		
Proportion of population providing unpaid care	-0.113	-1.099***	-1.008***	-0.903***	-0.904***	-1.150***
	[0.393]	[0.161]	[0.167]	[0.151]	[0.155]	[0.180]
Proportion of population aged 16-74 with no qualifications	-0.277					
	[0.185]					
Proportion of households without a car	0.141					
	[0.136]					
Proportion of households that are owner occupied	-0.179					
	[0.157]					
Proportion of households that are one pensioner households	-0.439*					
	[0.238]					
Lone parent households with dependent children	-0.001					
	[0.112]					
Proportion of population aged 16-74 that are permanently sick	0.326**	0.532***	0.489***	0.471***	0.550***	0.573***
	[0.133]	[0.120]	[0.124]	[0.124]	[0.103]	[0.116]
Proportion of those aged 16-74 that are long-term unemployed	0.046					
	[0.099]					
Proportion of those aged 16-74 working agriculture	-0.070***	-0.080***	-0.074***	-0.066***	-0.060***	
	[0.021]	[0.013]	[0.013]	[0.012]	[0.011]	

Proportion of those aged 16-74 in professional occupations	-0.339**	-0.100	-0.052	-0.115	-0.105	-0.008
	[0.146]	[0.095]	[0.096]	[0.098]	[0.096]	[0.100]
IMD 2010 Squared			0.133**	0.132**	0.129**	0.204***
			[0.064]	[0.059]	[0.060]	[0.064]
Constant	2.542**	2.020***	3.146***	3.191***	3.658***	3.929***
	[1.116]	[0.578]	[0.829]	[0.804]	[0.683]	[0.753]
Observations	151	151	151	151	151	151

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

With both the public health grant and healthcare as the expenditure variables: backward selection

Estimation of equation (1) with both public health and healthcare expenditure as endogenous regressors generates the result shown in column 1 of table A3. This specification includes five instruments (two for public health expenditure and three for healthcare expenditure). The corresponding first-stage results can be found in column 1 (for public health) and in column 2 (for healthcare) in table A4.

Some authors have expressed concern about the inclusion of weak instruments,[4] and hence we re-estimate the 'full' specification without the two insignificant MFF instruments (see column 2 of table A3). Application of the backward selection process generates the more parsimonious result shown in column 3 but the instrument set is invalid at the 1% level. On checking to see if any of the deleted variables or their squared values is significant when added as a control to the second-stage, we found that the 'permanently sick' variable squared is both significant and resolves the weak instrument issue for healthcare expenditure. Again in the interests of clarity, we tried re-estimating the specification in column 4 without the 'white ethnicity' variable. This generates the plausible result shown in column 5 where both expenditure variables have the anticipated negative association with mortality, they are endogenous, the instrument set is valid, and the instrument sets for both endogenous variables are individually strong (the Sanderson-Windmeijer F-statistics are around ten or better).

Table A3 Derivation of preferred specification for public health expenditure with healthcare expenditure, backward selection, 2013/14

VARIABLES	(1) All causes 2013/14 PH & PB spend SYLLR 2013/14/15 outcome model instrument PH&PB spend weighted IV second stage backward selection full specification five instruments	(2) All causes 2013/14 PH & PB spend SYLLR 2013/14/15 outcome model instrument PH&PB spend weighted IV second stage backward selection full specification three instruments	(3) All causes 2013/14 PH & PB spend SYLLR 2013/14/15 outcome model instrument PH&PB spend weighted IV second stage backward selection derived specification three instruments	(4) All causes 2013/14 PH & PB spend SYLLR 2013/14/15 outcome model instrument PH&PB spend weighted IV second stage backward selection derived specification revised	(5) All causes 2013/14 PH & PB spend SYLLR 2013/14/15 outcome model instrument PH&PB spend weighted IV second stage backward selection derived specification revised
Public health spend per person, 2013/14	-0.024	-0.052	0.010	-0.037	-0.081**
	[0.037]	[0.038]	[0.033]	[0.034]	[0.034]
Healthcare spend per person, 2013/14	-0.551	-0.076	-0.869***	-0.662***	-0.672***
	[0.413]	[0.355]	[0.233]	[0.204]	[0.233]
IMD 2010	0.253***	0.231***	0.271***	0.281***	0.221***
	[0.062]	[0.078]	[0.067]	[0.063]	[0.063]
Proportion of all residents born outside the EU	-0.043*	-0.023	-0.054***	-0.042**	-0.084***
	[0.024]	[0.023]	[0.020]	[0.019]	[0.019]
Proportion of population in white ethnic group	0.226***	0.237***	0.192***	0.185***	
	[0.051]	[0.058]	[0.034]	[0.036]	
Proportion of population providing unpaid care	-0.399***	-0.466***	-0.376***	-0.372***	-0.479***
	[0.144]	[0.165]	[0.099]	[0.096]	[0.096]
Proportion of population aged 16-74 with no qualifications	-0.111	-0.089			
	[0.105]	[0.124]			
Proportion of households without a car	-0.033	-0.091			
	[0.087]	[0.083]			
Proportion of households that are owner occupied	0.090	0.103			
	[0.075]	[0.074]			
Proportion of households that are one pensioner households	-0.023	-0.035			
	[0.079]	[0.087]			
Lone parent households with dependent children	-0.048	0.023			
	[0.082]	[0.090]			
Proportion of population aged 16-74 that are permanently sick	0.237***	0.281***	0.176**	0.910***	1.187***
	[0.068]	[0.070]	[0.077]	[0.343]	[0.331]
Proportion of those aged 16-74 that are long-term unemployed	0.085	0.069			
	[0.060]	[0.067]			
Proportion of those aged 16-74 working agriculture	-0.007	-0.012			

	[0.013]	[0.010]			
Proportion of those aged 16-74 in professional occupations	-0.259***	-0.243***	-0.244***	-0.223***	-0.194***
	[0.072]	[0.083]	[0.039]	[0.040]	[0.045]
Proportion of population aged 16-74 that are permanently sick, squared				0.111**	0.138***
				[0.053]	[0.052]
Constant	8.714***	5.636**	10.645***	10.605***	11.286***
	[2.852]	[2.502]	[1.379]	[1.132]	[1.409]
Observations	150	150	150	150	150
Endogeneity test statistic	5.928	9.295	6.089	9.906	17.683
Endogeneity p-value	0.052	0.010	0.048	0.007	0.000
Hansen-Sargan test statistic	20.849	9.099	6.810	6.458	1.667
Hansen-Sargan p-value	0.000	0.003	0.009	0.011	0.197
Kleibergen-Paap LM test statistic	9.027	6.363	16.219	15.540	16.034
Kleibergen-Paap p-value	0.060	0.042	0.000	0.000	0.000
Kleibergen-Paap F statistic	2.323	2.663	9.390	8.971	8.979
Pesaran-Taylor reset statistic	1.405	6.440	0.528	0.330	0.175
Pesaran-Taylor p-value	0.236	0.011	0.467	0.565	0.676
Sanderdson-Windmejer Public health spend F-statistic	70.796	36.048	51.105	78.626	70.796
Sanderdson-Windmejer Public health spend p-value	0.000	0.000	0.000	0.000	0.000
Sanderdson-Windmejer Healthcare spend F-statistic	13.469	3.008	4.288	13.427	13.469
Sanderdson-Windmejer Healthcare spend p-value	0.000	0.021	0.016	0.000	0.000

Robust standard errors in brackets

*** p<0.01, ** p<0.05, * p<0.1

Table A4 First-stage regression results for derivation of preferred specification for public health expenditure with healthcare expenditure, backward selection, 2013/14

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	All causes	All causes	All causes	All causes	All causes	All causes	All causes	All causes	All causes	All causes
	2013/14 PH spend	2013/14 PB spend	2013/14 PH spend	2013/14 PB spend	2013/14 PH spend	2013/14 PB spend	2013/14 PH spend	2013/14 PB spend	2013/14 PH spend	2013/14 PB spend
	SYLLR 2013/14/15	SYLLR 2013/14/15	SYLLR 2013/14/15	SYLLR 2013/14/15	SYLLR 2013/14/15	SYLLR 2013/14/15	SYLLR 2013/14/15	SYLLR 2013/14/15	SYLLR 2013/14/15	SYLLR 2013/14/15
	outcome model	outcome model	outcome model	outcome model	outcome model	outcome model	outcome model	outcome model	outcome model	outcome model
	first-stage	first-stage	first-stage	first-stage	first-stage	first-stage	first-stage	first-stage	first-stage	first-stage
	weighted	weighted	weighted	weighted	weighted	weighted	weighted	weighted	weighted	weighted
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	backward selection	backward selection	backward selection	backward selection	backward selection	backward selection	backward selection	backward selection	backward selection	backward selection
	full specification	full specification	full specification	full specification	derived specification	derived specification	derived specification	derived specification	derived specification	derived specification
VARIABLES	five instruments	five instruments	three instruments	three instruments	three instruments	three instruments	revised	revised	revised	revised
DFT index_Public health_1314	0.727***	-0.029	0.724***	-0.028	0.748***	0.018	0.750***	0.017	0.746***	0.017
	[0.056]	[0.021]	[0.057]	[0.022]	[0.054]	[0.027]	[0.052]	[0.028]	[0.056]	[0.028]
Healthcare_DFT_index	0.427	0.351**	0.360	0.410***	0.715**	0.614***	0.548*	0.671***	0.403	0.669***
	[0.437]	[0.138]	[0.407]	[0.146]	[0.312]	[0.153]	[0.330]	[0.161]	[0.343]	[0.155]
Prescribing_Age_index	-1.067***	0.016	-1.201***	0.037	-1.490***	0.208***	-1.380***	0.169**	-1.233***	0.172**
	[0.271]	[0.083]	[0.263]	[0.082]	[0.240]	[0.074]	[0.269]	[0.078]	[0.242]	[0.069]
MFF Index_Public health_1314	1.264	0.490								
	[1.106]	[0.378]								
HCHS_MFF_index	-1.921	-0.240								
	[1.232]	[0.388]								
IMD 2010	0.126	-0.018	0.179	-0.046	0.132	0.028	0.215*	-0.000	0.162	-0.001
	[0.137]	[0.054]	[0.134]	[0.055]	[0.105]	[0.057]	[0.112]	[0.059]	[0.116]	[0.056]
Proportion of all residents born outside the EU	0.014	-0.034**	0.003	-0.037***	0.022	-0.042***	0.019	-0.041***	-0.021	-0.041***
	[0.049]	[0.013]	[0.049]	[0.013]	[0.033]	[0.013]	[0.034]	[0.013]	[0.029]	[0.013]
Proportion of population in white ethnic group	0.284	0.007	0.322*	-0.025	0.239**	-0.007	0.209*	0.004		
	[0.175]	[0.041]	[0.182]	[0.042]	[0.098]	[0.041]	[0.109]	[0.042]		
Proportion of population providing unpaid care	0.024	-0.029	0.128	-0.080	-0.123	-0.275***	-0.136	-0.270***	-0.303	-0.273***
	[0.328]	[0.105]	[0.344]	[0.109]	[0.221]	[0.088]	[0.222]	[0.087]	[0.199]	[0.078]
Proportion of population aged 16-74 with no qualifications	-0.212	-0.055	-0.252	-0.048						
	[0.154]	[0.063]	[0.157]	[0.064]						
Proportion of households without a car	0.095	0.124***	0.082	0.112***						
	[0.137]	[0.039]	[0.140]	[0.040]						
Proportion of households that are owner occupied	-0.042	-0.000	-0.057	-0.036						
	[0.127]	[0.049]	[0.123]	[0.047]						
Proportion of h'holds that are one pensioner households	-0.052	0.080	-0.042	0.073						
	[0.283]	[0.057]	[0.268]	[0.060]						
Lone parent households with dependent children	-0.010	-0.162***	-0.061	-0.143***						
	[0.116]	[0.037]	[0.103]	[0.037]						
Proportion of aged 16-74 that are permanently sick	0.342***	0.030	0.331**	0.034	0.487***	0.030	1.285**	-0.246	1.542***	-0.242
	[0.128]	[0.055]	[0.128]	[0.057]	[0.124]	[0.066]	[0.572]	[0.217]	[0.492]	[0.207]
Proportion of those 16-74 that are long-term unemployed	0.055	0.089***	0.056	0.093***						
	[0.084]	[0.033]	[0.086]	[0.033]						
Proportion of those aged 16-74 working agriculture	-0.038*	0.019***	-0.034*	0.015**						
	[0.019]	[0.006]	[0.019]	[0.006]						
Proportion of those aged 16-74 in professional occupations	-0.298**	-0.097**	-0.351**	-0.069	-0.157*	-0.063*	-0.105	-0.081**	-0.079	-0.080**
	[0.132]	[0.047]	[0.135]	[0.047]	[0.092]	[0.037]	[0.102]	[0.038]	[0.104]	[0.037]
Proportion of 16-74 that are permanently sick, squared							0.132	-0.046	0.161**	-0.045

							[0.089]	[0.034]	[0.080]	[0.033]
Constant	3.987***	7.244***	3.774***	7.249***	4.584***	6.254***	5.539***	5.923***	5.737***	5.927***
	[1.015]	[0.401]	[1.017]	[0.399]	[0.680]	[0.347]	[0.886]	[0.438]	[0.854]	[0.428]
Observations	150	150	150	150	150	150	150	150	150	150

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

With both the public health grant and healthcare as the expenditure variables: forward selection

The use of backward selection to identify relevant covariates when theory provides little guidance does not always meet with universal approval, and hence we also report results using forward selection (see table A5 for the second-stage and table A6 for the first-stage results). Column 1 of table A5 shows the result with the inclusion of the most significant single control ('permanently sick') with the same five instruments from the 'full' specification in table A3. The Hansen-Sargan test statistic suggests that the instrument set is not valid and, in response to this, we re-estimate without the two insignificant MFF instruments. This re-estimation (see column 2 of table A5) largely resolves the instrument validity issue. Further re-estimation, with the inclusion of additional significant controls, generates the results shown in columns 3, 4 and 5. No further additional significant controls could be found and, as the result in column 5 is both in line with both our theoretical priors and passes the appropriate statistical tests, this is our preferred specification using forward selection.

Table A5 Derivation of preferred specification for public health expenditure with healthcare expenditure, forward selection, 2013/14

	(1)	(2)	(3)	(4)	(5)
	All causes	All causes	All causes	All causes	All causes
	2013/14 PH & PB spend	2013/14 PH & PB spend	2013/14 PH & PB spend	2013/14 PH & PB spend	2013/14 PH & PB spend
	SYLLR 2013/14/15	SYLLR 2013/14/15	SYLLR 2013/14/15	SYLLR 2013/14/15	SYLLR 2013/14/15
	outcome model	outcome model	outcome model	outcome model	outcome model
	instrument PH&PB spend	instrument PH&PB spend	instrument PH&PB spend	instrument PH&PB spend	instrument PH&PB spend
	weighted	weighted	weighted	weighted	weighted
	IV second stage	IV second stage	IV second stage	IV second stage	IV second stage
	forward selection	forward selection	forward selection	forward selection	forward selection
	round 1	round 1	round 2	round 3	round 4
VARIABLES	five instruments	three instruments	three instruments	three instruments	three instruments
Public health spend per person, 2013/14	-0.006	-0.004	-0.128***	-0.107***	-0.144***
	[0.025]	[0.028]	[0.040]	[0.041]	[0.040]
Healthcare spend per person, 2013/14	-1.012***	-1.394***	-0.949***	-1.190***	-0.837***
	[0.244]	[0.266]	[0.238]	[0.263]	[0.269]
Proportion of population aged 16-74 that are permanently sick	0.554***	0.603***	0.697***	0.707***	0.601***
	[0.031]	[0.035]	[0.046]	[0.046]	[0.051]
Proportion of population providing unpaid care			-0.289***	-0.571***	-0.547***
			[0.081]	[0.134]	[0.122]
Proportion of all residents born outside the EU				-0.059***	-0.070***
				[0.021]	[0.019]
Proportion of those aged 16-74 that are long-term unemployed					0.156***
					[0.040]
Constant	15.008***	17.848***	14.831***	15.692***	13.666***
	[1.756]	[1.913]	[1.719]	[1.742]	[1.762]
Observations	150	150	150	150	150
Endogeneity test statistic	6.137	17.111	21.226	20.194	22.853
Endogeneity p-value	0.046	0.000	0.000	0.000	0.000
Hansen-Sargan test statistic	23.780	2.997	0.032	1.702	1.465
Hansen-Sargan p-value	0.000	0.083	0.857	0.192	0.226
Kleibergen-Paap LM test statistic	24.002	19.635	19.756	17.814	18.331
Kleibergen-Paap p-value	0.000	0.000	0.000	0.000	0.000
Kleibergen-Paap F statistic	7.220	10.806	12.647	11.051	11.627
Pesaran-Taylor reset statistic	0.073	0.054	0.069	0.005	0.466
Pesaran-Taylor p-value	0.788	0.816	0.793	0.946	0.495

Sanderdson-Windmejer Public health spend F-statistic	100.608	183.202	76.326	66.169	57.002
Sanderdson-Windmejer Public health spend p-value	0.000	0.000	0.000	0.000	0.000
Sanderdson-Windmejer Healthcare spend F-statistic	9.052	16.288	19.070	16.633	17.375
Sanderdson-Windmejer Healthcare spend p-value	0.000	0.000	0.000	0.000	0.000

Robust standard errors in brackets

*** p<0.01, ** p<0.05, * p<0.1

Table A6 First-stage regression results for derivation of preferred specification for public health expenditure with healthcare expenditure, forward selection, 2013/14

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	All causes 2013/14 PH spend SYLLR 2013/14/15 outcome model first-stage weighted OLS forward selection round 1	All causes 2013/14 PB spend SYLLR 2013/14/15 outcome model first-stage weighted OLS forward selection round 1	All causes 2013/14 PH spend SYLLR 2013/14/15 outcome model first-stage weighted OLS forward selection round 1	All causes 2013/14 PB spend SYLLR 2013/14/15 outcome model first-stage weighted OLS forward selection round 1	All causes 2013/14 PH spend SYLLR 2013/14/15 outcome model first-stage weighted OLS forward selection round 2	All causes 2013/14 PB spend SYLLR 2013/14/15 outcome model first-stage weighted OLS forward selection round 2	All causes 2013/14 PH spend SYLLR 2013/14/15 outcome model first-stage weighted OLS forward selection round 3	All causes 2013/14 PB spend SYLLR 2013/14/15 outcome model first-stage weighted OLS forward selection round 3	All causes 2013/14 PH spend SYLLR 2013/14/15 outcome model first-stage weighted OLS forward selection round 4	All causes 2013/14 PB spend SYLLR 2013/14/15 outcome model first-stage weighted OLS forward selection round 4
VARIABLES	five instruments	five instruments	three instruments	three instruments	three instruments	three instruments	three instruments	three instruments	three instruments	three instruments
DFT index_Public health_1314	0.729***	0.025	0.728***	0.026	0.725***	0.024	0.723***	0.009	0.715***	0.007
	[0.055]	[0.026]	[0.056]	[0.026]	[0.058]	[0.025]	[0.061]	[0.025]	[0.059]	[0.026]
MFF Index_Public health_1314	0.832	0.550								
	[1.006]	[0.416]								
Healthcare_DFT_index	0.633**	0.579***	0.504*	0.552***	0.373	0.457***	0.383	0.526***	0.447	0.542***
	[0.291]	[0.127]	[0.272]	[0.116]	[0.279]	[0.119]	[0.277]	[0.114]	[0.285]	[0.115]
Prescribing_Age_index	-1.591***	0.143**	-1.530***	0.147***	-1.326***	0.296***	-1.338***	0.206***	-1.263***	0.225***
	[0.146]	[0.059]	[0.095]	[0.039]	[0.199]	[0.068]	[0.228]	[0.067]	[0.235]	[0.070]
HCHS_MFF_index	-1.335	-0.729								
	[1.119]	[0.450]								
Proportion of 16-74 that are permanently sick	0.639***	0.065***	0.673***	0.073***	0.711***	0.101***	0.710***	0.094***	0.654***	0.080***
	[0.049]	[0.018]	[0.030]	[0.012]	[0.042]	[0.016]	[0.044]	[0.015]	[0.054]	[0.022]
Proportion of population providing unpaid care					-0.260	-0.189***	-0.268	-0.250***	-0.304	-0.259***
					[0.193]	[0.067]	[0.193]	[0.069]	[0.193]	[0.071]
Proportion of all residents born outside the EU							-0.004	-0.030***	-0.016	-0.033***
							[0.026]	[0.010]	[0.027]	[0.011]
Proportion of 16-74 that are long-term unemployed									0.091	0.023
									[0.058]	[0.028]
Constant	5.844***	7.257***	5.958***	7.286***	5.490***	6.945***	5.458***	6.708***	5.534***	6.727***
	[0.157]	[0.057]	[0.096]	[0.040]	[0.357]	[0.125]	[0.388]	[0.146]	[0.395]	[0.144]
Observations	150	150	150	150	150	150	150	150	150	150

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

References for appendices

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