

## The causal impact of social care, public health and healthcare expenditure on mortality in England: cross-sectional evidence for 2013/14

### Appendices

#### Appendix A1: Further details about the instruments for healthcare expenditure

For 2013/14 the Department of Health allocated each Clinical Commissioning Group (CCG) a fixed proportion of the national budget (£65bn). CCGs used this allocation to fund expenditure on most types of healthcare except primary care, specialised commissioning and public health. CCGs reported their actual expenditure across various programmes of care and this data can be found in the programme budgeting dataset. This is available from <https://www.england.nhs.uk/programme-budgeting/> [accessed 05 September 2020].

Healthcare expenditure is instrumented in a similar way to social care expenditure and in line with equation (2) in the main text. The selection of the relevant funding rule variables for healthcare expenditure for 2013/14 is more difficult than usual due to the changes enacted by the Health and Social Care Act 2012. Normally, resource allocation formulae are updated annually but the approaching replacement of Primary Care Trusts (one set of local health authorities) with CCGs (a different set with different responsibilities) led to the freezing of the weighted capitation formula for 2012/13, with all Primary Care Trusts (PCTs) receiving the same (3%) growth rate over their 2011/12 allocations. Because CCGs were not responsible for the same set of services as PCTs (CCGs lost responsibility for primary care public health, specialised services, and primary care), there was a baseline exercise in 2012 that identified actual PCT expenditure on CCG service responsibilities and, for 2013/14, each CCG enjoyed an uplift of 2.3% on these 2012/13 baselines.

As a result of these changes, the most appropriate funding rule variables for CCG healthcare expenditure in 2013/14 are drawn from the 2011/12 allocations for PCTs, appropriately converted to the new (CCG) geography. These allocations reflect components of the funding formulae (one for the total allocation, one for Hospital and Community Health Services (HCHS), and one for prescribing), and we select three funding rule variables employed in these formulae which we believe are uncorrelated with mortality. More precisely, the funding rule variables for CCG

healthcare expenditure for 2013/14 are: (i) the age index from the prescribing component of the total allocation; (ii) the MFF for the HCHS component of the total allocation; and (iii) the DFT for the total allocation to PCTs for 2011/12.

### **Appendix A2: Further details about the instruments for local public health expenditure**

The resource allocation formula used to distribute the total public health budget to local authorities has three components. These are for substance misuse services, for non-mandatory services, and for mandatory services. Each of these three service areas has its own resource allocation formula but each formula has a similar structure to that outlined in equation (2) in the main text and two of the four variables in equation (2) (the MFF and the DFT) are present for all three components. Hence we use these variables as instruments for public health expenditure.

### **Appendix A3 Are the selected instruments valid?**

We noted in section 3 that valid instruments should be both uncorrelated with unobserved determinants of expenditure and mortality (i.e., instruments should be exogenous) and excludable from the second-stage regression equation (i.e., have no direct impact on mortality other than through their impact on expenditure). Let us consider whether the proposed instruments for our three expenditure variables are likely to meet these requirements.

#### *The MFF instrument for healthcare, public health and social care expenditure*

The MFF (input price index) adjustment reflects prices in the local health economy and is used as an instrument for all three types of expenditure. It is designed to compensate health authorities for the unavoidable higher costs they incur when hiring staff and buying other goods and services. If the MFF adjustment is perfect then each authority would be able to buy the same bundle of inputs. The instrument could have no impact on mortality because it has no impact on real expenditure. In practice, however, the MFF adjustment will be imperfect and these imperfections will generate differences in the volume of real resources available to health authorities (we assume that this error is small relative to the adjustment for local prices). We have no reason to believe that errors in the MFF adjustment will have any effect on mortality other than through their effect on expenditure (this is required for the excludability assumption). However, the MFF index reflects characteristics of the local (health) economy that could potentially be correlated with unmeasured determinants of

mortality and this instrument's exogeneity is therefore conditional on the socio-economic variables included in the estimated specification.

#### *The age-cost index instrument for healthcare*

A similar argument can be made for the age-cost index that is used as an instrument for healthcare expenditure. This is designed to compensate health authorities for the unavoidable additional expenditure they incur due to the demographic profile of their population. If the age-cost adjustment is perfect for every health authority then all authorities would be able to offer the same level of healthcare irrespective of whether their population is a particularly old or young one. Again, this (age-cost) index will be a useful predictor of nominal expenditure but, if the adjustment is perfect, this instrument can have no impact on mortality because it has no impact on real expenditure. Although an imperfect age-cost adjustment will generate differences in the volume of real resources available to health authorities, there is no reason to believe that these errors will have any effect on mortality other than through their effect on expenditure. The age-cost index reflects the impact of the local population's demographic profile on healthcare costs. As is the case for the MFF, this profile could potentially be correlated with unmeasured determinants of mortality and this instrument's exogeneity is therefore conditional on the control variables employed in the estimated specification.

#### *The distance from target index instrument for public health and healthcare expenditure*

The share of the national budget for both public health and healthcare expenditure apportioned to each health authority is governed by the Department of Health's allocation formula or 'funding rule'. This reflects each authority's need for expenditure and this, in turn, reflects the authority's population size, its age profile, local input prices, and other 'need for health care' factors. Periodically, the Department of Health revises its funding rule and this, together with data updates, generates a new target allocation for each authority. The new funding rule might generate a large change in the target allocation for some authorities and, to avoid sudden large reductions in actual budgets, such changes are usually incorporated into annual budgets over a number of years. The DFT index measures how far an authority's actual budget is below or above its target allocation.

A DFT index is used as an instrument for public health and healthcare expenditure. The DFT for healthcare will reflect the various funding formulae and 'pace of change' policies implemented under several governments of various political persuasions over the past thirty years. While there are undeniably policy choices involved, such as the setting of the 'pace of change' (POC) adjustment that transitions PCTs towards their target, over the recent past the POC policy focussed

on providing a minimum basic budget uplift for all authorities with a larger increase for those that were most under-target. We have no evidence to suggest that these policy choices were made on the basis of other factors such as outcomes (excludability). Moreover, health authority allocations usually include a relatively small component that seeks to address health inequalities directly and it is at this point that outcomes are considered rather than at the POC policy stage. We also have no evidence to suggest that, conditional on our controls, the DFT index will be correlated with unmeasured/unobserved determinants of mortality (exogeneity).

As noted above, a DFT index reflects how far an authority's actual budget is from its target allocation. This difference will reflect the product of three factors for the public health DFT index: (i) the size of PCT expenditure in 2010/11 on those public health activities that were transferred to local authorities in 2013/14; (ii) the public health grant funding formula for 2013/14; and (iii) the 'pace of change' policy for the 2013/14 public health allocations (i.e., the extent to which actual allocations for 2013/14 moved budgets away from what had been spent on public health by PCTs and towards the target allocations generated by the new funding rule for 2013/14). We have no evidence to suggest that the resulting public health DFT was selected on the basis of factors such as mortality (excludability assumption). We also have no evidence to suggest that, conditional on our controls, the public health DFT index will be correlated with unmeasured/unobserved determinants of mortality (exogeneity).

#### *The population sparsity index as an instrument for social care expenditure*

The population sparsity index is designed to compensate health authorities for the unavoidable higher costs they incur by having to serve a sparsely populated area. If this sparsity adjustment is perfect then each authority would be perfectly compensated for any additional costs and be able to provide the same service level. The instrument could have no impact on mortality because it has no impact on real expenditure. In practice, of course, the sparsity adjustment will be imperfect and these imperfections will generate differences in the volume of real resources available to health authorities. As was the case for the MFF index, we have no reason to believe that errors in the sparsity adjustment will have any effect on mortality other than through their effect on expenditure. However, the sparsity index may be correlated with characteristics of the local (health) economy that could potentially be correlated with unmeasured determinants of mortality. This instrument's exogeneity is therefore conditional on the socio-economic variables included in the estimated specification.

*The type of local authority as an instrument for social care expenditure*

A study of the impact of LA expenditure on home care services claimed that social care expenditure will reflect the service eligibility policy employed by different LAs and that ‘the innate culture and perspective of the council...will drive the generosity of policies more than small differences in the health of the population’. The researchers proposed the use of a set of four dummy variables reflecting the type of LA (Shire, Unitary, Metropolitan, London) as instruments on the assumption that ‘similar’ LAs will have ‘similar’ eligibility policies and expenditure levels. Conditional on the controls for social care need, we have no reason to believe that there will be a direct effect of the type of LA on mortality. The type of LA could be correlated with unmeasured determinants of mortality and so this instrument’s exogeneity is also conditional on the socio-economic variables included in the estimated specification.

*The proportion of households that are owner occupied as an instrument for social care expenditure*

Conditional on the controls for social care need included in the estimated specification, we have no reason to believe that there will be a direct effect of the proportion of households that are owner occupied on mortality. The proportion of households that are owner occupied could be correlated with unmeasured determinants of mortality and so this instrument’s exogeneity is also conditional on the socio-economic variables included in the estimated specification.

In addition to the theoretical considerations outlined above, the validity of all instruments is tested empirically using the Hansen-Sargan test. The set of instruments associated with our preferred specifications pass this empirical test.

**Appendix A4**

This appendix contains the first-stage regressions associated with the second-stage results reported in the main body of the text.

Table A1 Obtaining a preferred health outcome specification for social care, healthcare and public health expenditure, backward selection, first-stage results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	All causes	All causes	All causes	All causes	All causes	All causes	All causes	All causes	All causes
	2013/14 PB spend	2013/14 G_SS spend	2013/14 PH spend	2013/14 PB spend	2013/14 G_SS spend	2013/14 PH spend	2013/14 PB spend	2013/14 G_SS 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	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
	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
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	parsimonious	parsimonious	parsimonious	parsimonious_v2	parsimonious_v2	parsimonious_v2	parsimonious_v3	parsimonious_v3	parsimonious_v3
VARIABLES									
DFT index, public health expenditure, 2013/14	0.011	0.054	0.737***	0.022	0.033	0.736***	0.021	0.039	0.755***
	[0.027]	[0.061]	[0.050]	[0.026]	[0.067]	[0.045]	[0.026]	[0.064]	[0.054]
MFF, public health expenditure, 2013/14	0.099	1.033	0.945						
	[0.438]	[1.010]	[1.016]						
DFT index, NHS healthcare expenditure	0.537***	0.012	0.590**	0.536***	0.009	0.587**	0.541***	0.045	0.633*
	[0.155]	[0.359]	[0.276]	[0.151]	[0.380]	[0.279]	[0.158]	[0.391]	[0.326]
Age index, prescribing cost formula	0.234***	0.230	-1.080***	0.226***	0.179	-1.129***	0.250***	0.077	-1.423***
	[0.084]	[0.197]	[0.270]	[0.084]	[0.201]	[0.276]	[0.076]	[0.208]	[0.262]
MFF, resource allocation HCHS formula	-0.425	-1.459	-1.619						
	[0.488]	[1.093]	[1.203]						
Type of LA: London borough	0.036	-0.113**	-0.034						
	[0.024]	[0.054]	[0.058]						
Type of LA: Metropolitan district	0.017	-0.113***	0.010	0.017	-0.068**	0.041	0.008	-0.056**	0.030
	[0.017]	[0.030]	[0.043]	[0.015]	[0.030]	[0.038]	[0.013]	[0.023]	[0.029]
Type of LA: Unitary authority	0.002	-0.025	0.053	0.003	0.004	0.075***			
	[0.011]	[0.026]	[0.032]	[0.009]	[0.026]	[0.028]			
Area cost adj for older people's social services	0.270	0.527	0.444	0.215	-0.131	-0.051			
	[0.281]	[0.590]	[0.454]	[0.182]	[0.425]	[0.407]			
Population sparsity measure	0.820	-4.418*	-8.406***	1.300**	-3.199	-6.998***			
	[0.719]	[2.314]	[2.403]	[0.653]	[2.360]	[2.250]			
% households that are owner occupied	-0.114**	-0.356***	-0.163	-0.107**	-0.466***	-0.233**	-0.148***	-0.377***	0.007
	[0.055]	[0.107]	[0.128]	[0.053]	[0.106]	[0.117]	[0.051]	[0.091]	[0.099]
Index of Multiple Deprivation 2010	-0.028	0.135	0.218*	-0.007	0.062	0.192*	-0.008	0.041	0.122
	[0.051]	[0.106]	[0.119]	[0.053]	[0.103]	[0.102]	[0.054]	[0.110]	[0.113]
% population in white ethnic group	0.079*	0.135*	0.152*	0.073*	0.208***	0.194**	0.073*	0.190***	0.180*
	[0.042]	[0.071]	[0.084]	[0.044]	[0.072]	[0.078]	[0.041]	[0.065]	[0.092]
% population providing unpaid care	-0.101	0.385*	-0.017	-0.073	0.429*	0.048	-0.053	0.340*	-0.270
	[0.092]	[0.230]	[0.205]	[0.091]	[0.220]	[0.207]	[0.093]	[0.194]	[0.236]
% population aged 16-74 permanently sick	0.039	-0.019	0.270**	0.036	0.007	0.284**	0.021	0.072	0.481***
	[0.061]	[0.116]	[0.111]	[0.061]	[0.118]	[0.110]	[0.059]	[0.111]	[0.124]
% aged 16-74 in managerial/prof occupations	-0.104**	0.211**	-0.121	-0.097**	0.186*	-0.129	-0.083**	0.183**	-0.158*
	[0.045]	[0.094]	[0.094]	[0.046]	[0.103]	[0.092]	[0.038]	[0.090]	[0.093]
Constant	6.841***	-0.557	3.800***	6.844***	-0.241	4.028***	6.863***	-0.166	4.191***
	[0.294]	[0.533]	[0.542]	[0.300]	[0.551]	[0.555]	[0.300]	[0.569]	[0.609]
Observations	150	150	150	150	150	150	150	150	150
Robust standard errors in brackets									
*** p<0.01, ** p<0.05, * p<0.1									

Table A1 continued (created by the authors)

## Obtaining a preferred health outcome specification for social care, healthcare and public health expenditure, backward selection, first-stage results

	(10)	(11)	(12)	(13)	(14)	(15)
	All causes	All causes	All causes	All causes	All causes	All causes
	2013/14 PB spend	2013/14 G_SS spend	2013/14 PH spend	2013/14 PB spend	2013/14 G_SS 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
	parsimonious_v4	parsimonious_v4	parsimonious_v4	parsimonious_v5	parsimonious_v5	parsimonious_v5
VARIABLES						
DFT index, public health expenditure, 2013/14	0.014 [0.027]	0.062 [0.055]	0.764*** [0.058]	0.027 [0.026]	0.083 [0.054]	0.761*** [0.056]
DFT index, NHS healthcare expenditure	0.592*** [0.158]	-0.136 [0.344]	0.566* [0.340]	0.594*** [0.161]	-0.131 [0.344]	0.565* [0.340]
Age index, prescribing cost formula	0.218*** [0.080]	0.190 [0.217]	-1.382*** [0.286]	0.227*** [0.085]	0.205 [0.226]	-1.384*** [0.284]
Type of LA: Metropolitan district	0.012 [0.013]	-0.069*** [0.023]	0.026 [0.029]	0.004 [0.013]	-0.082*** [0.024]	0.027 [0.027]
% households that are owner occupied	-0.175*** [0.051]	-0.282*** [0.100]	0.042 [0.117]			
Index of Multiple Deprivation 2010	0.195 [0.171]	-0.680* [0.351]	-0.145 [0.455]	0.079 [0.154]	-0.868** [0.350]	-0.117 [0.421]
% population in white ethnic group	0.078* [0.040]	0.173** [0.067]	0.173* [0.096]	0.063 [0.040]	0.149** [0.068]	0.177* [0.095]
% population providing unpaid care	-0.037 [0.092]	0.284 [0.205]	-0.291 [0.244]	-0.189** [0.094]	0.039 [0.207]	-0.254 [0.232]
% population aged 16-74 permanently sick	0.025 [0.058]	0.055 [0.107]	0.475*** [0.124]	0.056 [0.063]	0.104 [0.109]	0.467*** [0.124]
% aged 16-74 in managerial/prof occupations	-0.108*** [0.039]	0.273*** [0.096]	-0.125 [0.110]	-0.061 [0.041]	0.348*** [0.083]	-0.136 [0.103]
Index of Multiple Deprivation 2010 Squared	-0.038 [0.028]	0.137** [0.058]	0.051 [0.081]	-0.011 [0.025]	0.180*** [0.056]	0.044 [0.073]
Constant	6.615*** [0.382]	0.716 [0.736]	4.518*** [0.815]	6.605*** [0.361]	0.700 [0.763]	4.520*** [0.811]
Observations	150	150	150	150	150	150
Robust standard errors in brackets						
*** p<0.01, ** p<0.05, * p<0.1						

Table A2 Obtaining a preferred health outcome specification for social care, healthcare and public health expenditure, forward selection, first-stage results

	(1)	(2)	(3)	(4)	(5)	(6)
	All causes	All causes	All causes	All causes	All causes	All causes
	2013/14 PB spend	2013/14 G_SS spend	2013/14 PH spend	2013/14 PB spend	2013/14 G_SS 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
	'initial' specification	'initial' specification	'initial' specification	specification 2	specification 2	specification 2
VARIABLES						
DFT index, public health expenditure, 2013/14	0.004	0.062	0.716***	0.016	0.048	0.717***
	[0.029]	[0.059]	[0.054]	[0.027]	[0.063]	[0.049]
MFF, public health expenditure, 2013/14	0.032	1.017	0.375			
	[0.430]	[0.988]	[1.038]			
DFT index, NHS healthcare expenditure	0.444***	0.215	0.530*	0.460***	0.221	0.371
	[0.144]	[0.342]	[0.286]	[0.140]	[0.348]	[0.256]
Age index, prescribing cost formula	0.228***	0.246	-1.077***	0.220***	0.176	-1.062***
	[0.084]	[0.199]	[0.269]	[0.079]	[0.194]	[0.270]
MFF, resource allocation HCHS formula	-0.359	-1.523	-1.314			
	[0.482]	[1.074]	[1.213]			
Type of LA: London borough	0.030	-0.090*	-0.003			
	[0.026]	[0.052]	[0.050]			
Type of LA: Metropolitan district	0.015	-0.105***	0.020	0.016	-0.070**	0.063**
	[0.016]	[0.031]	[0.041]	[0.014]	[0.028]	[0.031]
Type of LA: Unitary authority	0.004	-0.029	0.060*	0.005	-0.003	0.085***
	[0.010]	[0.026]	[0.032]	[0.009]	[0.025]	[0.026]
Area cost adj for older people's social services	0.143	0.718	0.076			
	[0.254]	[0.626]	[0.460]			
Population sparsity measure	0.843	-4.433*	-8.279***	1.319**	-3.410	-5.890***
	[0.720]	[2.392]	[2.362]	[0.666]	[2.354]	[2.141]
% households that are owner occupied	-0.101*	-0.403***	-0.211*	-0.102*	-0.502***	-0.209*
	[0.053]	[0.107]	[0.123]	[0.052]	[0.101]	[0.121]
% population aged 16-74 permanently sick	0.052*	0.026	0.519***	0.066***	-0.014	0.567***
	[0.029]	[0.073]	[0.067]	[0.024]	[0.066]	[0.064]
% population providing unpaid care	-0.086	0.300	-0.180	-0.074	0.394*	-0.107
	[0.086]	[0.217]	[0.196]	[0.084]	[0.215]	[0.202]
% population in white ethnic group	0.050*	0.161**	0.014	0.041	0.248***	0.048
	[0.028]	[0.062]	[0.070]	[0.027]	[0.065]	[0.060]
Older adults: social service need per person						
Constant	6.962***	-0.480	4.991***	7.038***	-0.434	5.291***
	[0.158]	[0.403]	[0.367]	[0.150]	[0.370]	[0.382]
Observations	150	150	150	150	150	150
Robust standard errors in brackets						
***p<0.01, **p<0.05, *p<0.1						



Table A2 continued (created by the authors)

Obtaining a preferred health outcome specification for social care, healthcare and public health expenditure, forward selection, first-stage results

	(7)	(8)	(9)	(10)	(11)	(12)
	All causes	All causes	All causes	All causes	All causes	All causes
	2013/14 PB spend	2013/14 G_SS spend	2013/14 PH spend	2013/14 PB spend	2013/14 G_SS 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
VARIABLES	specification 3	specification 3	specification 3	preferred specification	preferred specification	preferred specification
DFT index, public health expenditure, 2013/14	0.012	0.057	0.734***	0.020	0.075	0.728***
	[0.026]	[0.064]	[0.057]	[0.026]	[0.061]	[0.056]
MFF, public health expenditure, 2013/14						
DFT index, NHS healthcare expenditure	0.413***	0.321	0.352	0.451**	0.291	0.255
	[0.132]	[0.351]	[0.285]	[0.127]	[0.338]	[0.284]
Age index, prescribing cost formula	0.266***	0.050	-1.345***	0.279***	0.212	-1.279***
	[0.072]	[0.210]	[0.253]	[0.077]	[0.207]	[0.257]
MFF, resource allocation HCHS formula						
Type of LA: London borough						
Type of LA: Metropolitan district	0.009	-0.057**	0.039	0.004	-0.080***	0.037
	[0.012]	[0.023]	[0.027]	[0.013]	[0.023]	[0.026]
Type of LA: Unitary authority						
Area cost adj for older people's social services						
Population sparsity measure						
% households that are owner occupied	-0.129***	-0.422***	0.026			
	[0.049]	[0.085]	[0.100]			
% population aged 16-74 permanently sick	0.056**	0.019	0.699***	0.069**	-0.088	0.610***
	[0.024]	[0.045]	[0.059]	[0.029]	[0.062]	[0.064]
% population providing unpaid care	-0.055	0.328*	-0.372	-0.158*	0.178	-0.245
	[0.088]	[0.191]	[0.227]	[0.085]	[0.191]	[0.212]
% population in white ethnic group	0.048*	0.235***	0.064	0.047*	0.294***	0.100
	[0.026]	[0.064]	[0.068]	[0.026]	[0.068]	[0.068]
Older adults: social service need per person				0.068	0.583***	0.193
				[0.058]	[0.113]	[0.120]
Constant	7.052***	-0.473	5.208***	6.925***	-0.914**	5.218***
	[0.154]	[0.361]	[0.421]	[0.152]	[0.360]	[0.423]
Observations	150	150	150	150	150	150
Robust standard errors in brackets						
*** p<0.01, ** p<0.05, * p<0.1						