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ORIGINAL ARTICLE

Unemployment, public-sector healthcare expenditure and colorectal cancer mortality in the European Union: 1990–2009

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Abstract
Objectives We examined the association between unemployment and government spending on healthcare with colorectal cancer mortality.
Methods Retrospective observational study using data from the World Bank and WHO. Multivariate regression analysis was used, controlling for country-specific differences in infrastructure and demographics.
Results A 1 % increase in unemployment was associated with a significant increase in colorectal cancer mortality in both men and women [men: coefficient (R) = 0.0995, 95 % confidence interval (CI) 0.0132–0.1858, $P = 0.024$; women: $R = 0.0742$, 95 % CI 0.0160–0.1324, $P = 0.013$]. A 1 % increase in government spending on healthcare was associated with a statistically significant decrease in colorectal cancer mortality across both sexes (men: $R = -0.4307$, 95 % CI −0.6057 to −0.2557, $P < 0.001$; women: $R = -0.2162$, 95 % CI −0.3407 to −0.0917, $P = 0.001$). The largest changes in mortality occurred 3–4 years following changes in either economic variable.
Conclusions Unemployment rises are associated with a significant increase in colorectal cancer mortality, whilst government healthcare spending rises are associated with falling mortality. This is likely due, in part, to reduced access to healthcare services and has major implications for clinicians and policy makers alike.

Keywords Colorectal cancer · Cancer mortality · Unemployment · Healthcare spending · European Union

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Introduction

Within the European Union (EU), colorectal cancer is the second most common tumour type, accounting for over 12 % of all EU cancer deaths in 2012 (Ferlay et al. 2013). As governments seek to drive down colorectal cancer mortality, a number of public health strategies such as screening programmes, advertising campaigns and fast-track referral systems have been employed (Hardcastle et al. 1996) (Robinson et al. 1999; Thompson 2002), with varying degrees of success. Whilst mean colorectal mortality rates have fallen across the EU from 22.2 to 20.5 per 100,000 population between 2000 and 2010, this effect was not uniformly observed across all member states (OECD 2012). A number of studies have documented associations between lower socioeconomic status (SES) and increased colorectal cancer mortality (Coleman et al. 2001; Du et al. 2007). We sought to further characterise this relationship by paying specific attention to unemployment and government spending on healthcare.

The global economic downturn has led to a number of European governments adopting radical economic policies to reduce budget deficits (McKee et al. 2012). Such policies have largely aimed to accomplish this through a series of tax rises and spending cuts, often directly leading to rising unemployment rates (Stuckler and Basu 2013). In some European countries unemployment has risen sharply, and this is likely to have been exacerbated by measures that reduce public-sector spending (Eurostat 2013b; European Parliamentary Research Service 2013). Additionally, there is evidence suggesting that the economic downturn has had direct implications for government spending on healthcare with EU governments pursuing fiscal consolidation measures that have significantly reduced healthcare expenditure (Keegan et al. 2013). Both reductions in government healthcare spending and unemployment have been linked with poorer public health outcomes. In Greece and Spain, for example, the downturn has been associated with outbreaks of infectious disease and rising all-cause mortality (Legido-Quigley et al. 2013; Stuckler et al. 2011), whilst unemployment has also been linked to increased mortality (Martikainen 1990). However, whilst recent research mainly focuses on all-cause mortality or suicidal deaths, there is a lack of detailed analyses on the effects of economic changes on specific diseases.

We investigated the impact of economic changes—both during and outside economic crises—on healthcare by looking at the relationship between aggregate unemployment and government healthcare expenditure on colorectal cancer mortality across the European Union between 1990 and 2009. Unemployment was chosen for its reliability as a macroeconomic indicator across a wide range of socioeconomic strata as well as for its direct impact on people's lives as compared to a more removed indicator such as GDP. We hypothesised that both variables would be independently associated with rises in colorectal cancer mortality attributable to a variety of factors, including reduced access to care.

Methods

Data collection

Colorectal cancer mortality data (deaths per 100,000) were obtained from the World Health Organization (WHO) mortality database. These data were available for 1990 to 2009 and are based on death certification updated annually from civil registration systems of member states (http://apps.who.int/healthinfo/statistics/mortality/whodpms/). The quality of the data has been evaluated by the WHO (Mathers et al. 2005). Age-standardised death rates (ASDR) were employed as the basis of the analysis and are defined by the WHO as the annual weighted average of age-specific mortality rate per 100,000 population, where the weights are the proportions of persons in the corresponding age groups of the WHO standard population. Socioeconomic data were obtained from the World Bank's Development Indicators and Global Development Finance 2013 edition for the period 1990–2009 (http://data.worldbank.org/data-catalog/world-development-indicators). Data were analysed for the 27 EU member states (Table 1), but only for the years when these countries were members of the EU. Since data was available up to 2009, Croatia—which joined the EU in 2013—was not included. Unemployment, as defined by the World Bank (http://data.worldbank.org/indicator/SL.UEM.TOTL.ZS), was taken to be the share of the labour force that is without work but available and seeking employment. Government healthcare spending was measured as a percentage of GDP (data code: SH.XPD.PUBL.ZS) and was defined by the World Bank as including all rent and capital spending from government budgets (central and local), external borrowings and grants (including donations from international agencies and nongovernmental organisations), and social (or compulsory) health insurance funds.

Statistical analysis

Multivariate regression analysis was used to assess the relationship between colorectal cancer mortality (dependent variable) and unemployment (independent variable). To ensure that results were not driven by extreme observations for certain countries, a fixed-effects approach was used in the regression models, including 27 dummy variables for the 27

Table 1 Unemployment and public health spending in 27 European Union countries in 1990 and 2009

Country	Year joining European Union	Unemployment 2009	Unemployment 1990	Public health spending 2009 (% of GDP)
Spain	1986	18	3.2	8.56
Latvia	2004	17.1	7.3	8.14
Estonia	2004	13.8	N/A	4.00
Lithuania	2004	13.7	N/A	2.55
Slovak Republic	2004	12.1	N/A	6.71
Ireland	1973	11.7	8.3	9.74
Hungary	2004	10	0.6	5.28
Greece	1981	9.5	3.1	6.76
Portugal	1986	9.5	9.4	9.27
France	1957	9.1	N/A	9.01
Sweden	1995	8.3	7	6.52
Finland	1995	8.2	N/A	5.28
Poland	2004	8.2	14.1	7.07
Belgium	1973	7.9	9.8	7.35
Italy	1957	7.8	N/A	4.07
Germany	1957	7.7	N/A	5.54
UK	1973	7.7	1.6	6.65
Malta	2004	6.9	N/A	5.52
Romania	2007	6.9	7.7	9.47
Bulgaria	2007	6.8	N/A	5.32
Czech Republic	2004	6.7	4.7	7.28
Denmark	1973	6	N/A	4.45
Slovenia	2004	5.9	N/A	6.00
Cyprus	2004	5.3	N/A	6.82
Luxembourg	1957	5.1	16	7.04
Austria	1995	4.8	1.8	8.15
The Netherlands	1957	3.4	6.8	8.24

Unemployment, as defined by the World Bank (http://www.data.worldbank.org/indicator/SL.UEM.TOTL.ZS), was taken to be the share of the labour force that is without work but available and seeking employment. Government healthcare spending was measured as a percentage of GDP (data code: SH.XPD.PUBL.ZS) to encompass all expenditure from government budgets (central and local) as well as external borrowings and grants (including donations from international agencies and nongovernmental organisations), and social (or compulsory) health insurance funds

countries in the dataset. Doing this meant that models evaluated mortality changes within individual countries whilst holding constant time-invariant differences between countries including higher predispositions to colorectal cancer as well as political, cultural, and structural differences. In effect, this conservative modelling approach made the data more comparable. The demographic structure of the selected countries was also controlled for by incorporating total population size, in addition to the percentage of the population over 65 years of age and less than 15 years old into the model. We used the Cook–Weisberg test (Cook and Weisberg 1983) to assess for and to confirm heteroskedasticity (where sub-samples have different distributions) in the data used. Therefore, robust standard errors were included in the regression models to account for heterogeneity in the unemployment and public-sector healthcare spending dataset due to, for example, differences in the way that countries measure unemployment rates and spending, in addition to underemployment, or social programmes (for example, back-to-work initiatives or programmes that see people move from employment into education or training) that may otherwise have hidden or suppressed actual unemployment rates. With the inclusion of several control variables (in turn losing degrees of freedom and reducing sample size), our approach was conservative. This methodology has been widely used in similar health-economic studies and is generally regarded as rigorous and conservative (Stuckler et al. 2009).

Our basic linear fixed-effects statistical model was, therefore:

$$H_{i,t} - H_{i,0} = \alpha_{i,t} + \left(U_{i,t} - U_{i,0}\right)\beta + \eta_t + \varepsilon_{i,t}$$

where i is country and t is year; H is the health metric (colorectal cancer mortality); U is the measure of unemployment; α represents the population structure of the country being analysed, η is a dummy variable for each country included in the regression model, and ε is the error term.

To determine the association between government spending on healthcare (measured as a percentage of GDP), the multivariate regression analysis was re-run using government health spending as an independent variable.

We conducted 1-, 2-, 3-, 4-, and 5-year time-lag multivariate analyses to quantify the long-term effects of changes in unemployment and government healthcare spending. Several robustness checks were also conducted; these are detailed in the results section.

To explore the suitability of other regression models, we also fitted pooled ordinary least squares (OLS) and random-effects models. To assess whether the consistent but inefficient fixed-effects model was more suitable than the potentially inconsistent but efficient pooled OLS and random-effects approaches, we conducted Hausman tests and found highly significant test results ($P < 2.2 \times 10^{-16}$ for both) leading us to reject the random-effects and pooled OLS approaches and their assumptions in favour of a fixed-effects model.

Stata SE version 12 was used for the analysis (Stata Corporation, TX, USA).

Results

Unemployment and colorectal cancer mortality

Table 2 and Fig. 1 display the results of five regression models in 27 EU in the period 1990–2009. The results displayed are adjusted for population size, demographic structure, and inter-country differences in infrastructure.

The results show that a 1 % rise in unemployment is associated with a statistically significant rise in colorectal cancer mortality in both men [coefficient (R) = 0.0995, 95 % CI 0.0132–0.1858, $P < 0.024$) and women ($R = 0.0742$, 95 % CI 0.0160–0.1324, $P < 0.013$). Given the current population size across the 27 EU counties (Eurostat 2013a), this equates to 501 excess deaths in men and 374 excess deaths in women per 1 % increase in unemployment rates, without incorporating lagged or long-term effects of unemployment changes.

Government healthcare spending and colorectal cancer mortality

Table 3 displays the results of similar models re-run to examine the effect of increases in government healthcare spending, measured as a percentage of GDP, on colorectal cancer mortality.

The results show that a 1 % increase in government spending on healthcare is associated with a significant decrease in colorectal cancer deaths in both men ($R = -0.4307$, 95 % CI −0.6057 to −0.2557, $P < 0.001$) and women ($R = -0.2162$, 95 % CI −0.3407 to −0.0917, $P < 0.001$). This equates to a reduction of 2170 deaths in men and 1090 deaths in women per 1 % increase in government healthcare expenditure, without incorporating lagged or long-term effects of spending changes.

Table 2 Unemployment and colorectal cancer mortality in 27 European Union countries between 1990 and 2009

	Coefficient	Standard error	*P* value	95 % CI (low)	95 % CI (high)
(A) Men					
Year 0	0.10	0.04	0.0239*	0.01	0.19
Year 1	0.12	0.05	0.0091**	0.03	0.21
Year 2	0.13	0.04	0.0032**	0.04	0.22
Year 3	0.14	0.04	0.0014**	0.06	0.23
Year 4	0.19	0.04	0.0000***	0.11	0.28
Year 5	0.17	0.04	0.0000***	0.09	0.25
(B) Women					
Year 0	0.07	0.03	0.0126*	0.02	0.13
Year 1	0.13	0.03	0.0000***	0.07	0.18
Year 2	0.13	0.03	0.0000***	0.07	0.18
Year 3	0.15	0.03	0.0000***	0.09	0.20
Year 4	0.14	0.03	0.0000***	0.09	0.20
Year 5	0.13	0.03	0.0000***	0.07	0.18

Increases in colorectal cancer mortality (coefficient) following a 1 % rise in the unemployment rate in years 0–5 in men (A) and women (B) are shown. Coefficients, their 95 % confidence intervals, standard errors and the corresponding levels of significance (*P* values) were computed through fixed-effects regression

Sources: Colorectal cancer mortality per 100,000—World Health Organisation Mortality Data and Statistics; http://www.who.int/healthinfo/statistics/mortality/en/index.html

Economic and population data: World Bank Development Indicators 2013; http://data.worldbank.org/data-catalog/world-development-indicators

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Lag analysis

Further analysis was performed to investigate whether the two associations lasted in the long term (Tables 2, 3; Figs. 1, 2). Colorectal cancer mortality continued to increase up to 5 years following a 1 % rise in unemployment in both men (1 year: $R = 0.1195$, $P = 0.009$; 3 years: $R = 0.1443$, $P = 0.001$; and 5 years: $R = 0.1702$, $P < 0.0001$) and women (1 year: $R = 0.1254$, $P = 0.013$; 3 years: $R = 0.1475$, $P < 0.0001$; and 5 years: $R = 0.1262$, $P < 0.0001$). In both men and women, the effect at 3 years was larger than the effect in year 0 (Table 2; Fig. 1).

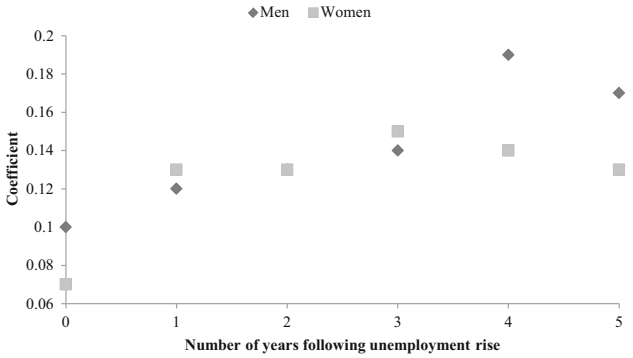

Fig. 1 Scatter plot displaying how the association between colorectal cancer mortality and unemployment changes with time. European Union, 1990–2009. Coefficients (*y* axis) were calculated through a fixed-effects regression analysis of 27 EU member countries for both male (*diamonds*) and female (*squares*) colorectal cancer mortality rates against unemployment rates. Lag analyses of 1 to 5 years (*x* axis) were performed to test the durability of these associations. Colorectal cancer mortality continued to increase in the years following an unemployment rise with the effect at 3 years larger than the effect at year 0 for both men and women. Confidence intervals and *P* values are displayed in Table 2

A similar trend was seen following changes in government healthcare spending with increases in spending leading to a significant reduction in colorectal cancer mortality for up to 3 years in men (1 year: $R = -0.2684$, $P < 0.002$; 3 years: $R = -0.2188$, $P = 0.035$); and 4 years in women (1 year: $R = -0.1895$, $P = 0.012$; 4 years: $R = -0.1839$, $P = 0.009$) (Table 3; Fig. 2).

Robustness checks

To control for confounding factors, the analysis was repeated with a number of controls included (Tables 4, 5). First, to control for economic factors, we introduced variables to account for changes in GDP per capita, inflation and interest rates. Second, we controlled for urbanisation and nutrition (mean calorie intake) to account for variations in infrastructure and diet. Finally, we controlled for out-of-pocket expenses, which can affect access to healthcare, and found across both men and women that the two associations already described—between unemployment and colorectal mortality and government healthcare spending and colorectal mortality—remained statistically significant

Table 3 Government healthcare spending and colorectal cancer mortality in 27 European Union countries between 1990 and 2009

	Coefficient	Standard error	*P* value	95 % CI (low)	95 % CI (high)
(A) Men					
Year 0	−0.43	0.09	0.0000***	−0.61	−0.26
Year 1	−0.27	0.08	0.0017**	−0.44	−0.10
Year 2	−0.22	0.10	0.0242*	−0.41	−0.03
Year 3	−0.22	0.10	0.0354*	−0.42	−0.02
Year 4	−0.21	0.12	0.0816	−0.44	0.03
Year 5	−0.13	0.12	0.3082	−0.37	0.12
(B) Women					
Year 0	−0.22	0.06	0.0007***	−0.34	−0.09
Year 1	−0.19	0.08	0.0122*	−0.34	−0.04
Year 2	−0.21	0.07	0.0042**	−0.35	−0.07
Year 3	−0.14	0.06	0.0128*	−0.26	−0.03
Year 4	−0.18	0.07	0.0092**	−0.32	−0.05
Year 5	−0.04	0.08	0.6416	−0.21	0.13

Increases in colorectal cancer mortality (coefficient) following a 1 % rise in government spending on healthcare (% of GDP) in years 0–5 in men (A) and women (B) are shown. Coefficients, their 95 % confidence intervals, standard errors and the corresponding levels of significance (*P* values) were computed through fixed-effects regression

Sources: Colorectal cancer mortality per 100,000—World Health Organisation Mortality Data and Statistics; http://www.who.int/healthinfo/statistics/mortality/en/index.html

Economic and population data: World Bank Development Indicators 2013; http://data.worldbank.org/data-catalog/world-development-indicators

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

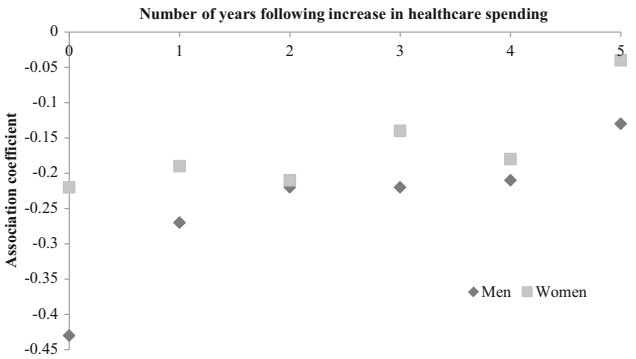

Fig. 2 Scatter plot displaying how the association between colorectal cancer mortality and healthcare expenditure changes with time. European Union, 1990–2009. Coefficients (*y* axis) were calculated through a fixed effects regression analysis of 27 EU member countries for both male (*diamonds*) and female (*squares*) colorectal cancer mortality rates against government health spending. Lag analyses of 1–5 years (*x* axis) were performed to test the durability of these associations. Colorectal cancer is reduced from baseline for up to 5 years following an increase in healthcare expenditure. Confidence intervals and *P* values are displayed in Table 3

in year 0, and, in most cases, remain statistically significant up to 3 years following any change (Tables 4, 5). The exception to this was when controlling for out-of-pocket expenses (OOPE) on healthcare for both men and women in the unemployment dataset (Tables 4, 5).

Out-of-pocket expenditure subgroup analysis

To more specifically determine the impact of OOPE on healthcare we conducted a subgroup analysis, splitting EU member states into those with OOPE on healthcare (as a proportion of total health expenditure) above or below 13.9 % as of 2009. Countries with OOPE below this threshold ($n = 8$) were identified by the International Labour Organisation (ILO) as having very low poverty rates (International Labour Organisation 2011). We found that despite substantially reduced sample sizes, countries with OOPE above 13.9 % ($n = 19$) continued to display a significant association between unemployment and male colorectal cancer mortality, in addition to a significant association between government healthcare spending and female colorectal cancer mortality. In contrast, countries with OOPE below 13.9 % displayed no association between either unemployment or spending and mortality (Table 6).

Discussion

Principal findings

This study has shown that across the 27 member states of the EU between 1990 and 2009 there is an association between unemployment and colorectal cancer mortality, and government healthcare spending and colorectal cancer mortality. Every 1 % increase in unemployment was associated with nearly 900 excess deaths, whilst every 1 % increase in government healthcare spending was associated with a reduction of 3260 deaths, excluding lagged effects. These associations lasted long after changes in unemployment or government healthcare spending with a statistically significant increase in mortality 5 years following a 1 % unemployment rise and up to 4 years following a 1 % spending change. The relationship between both unemployment and government healthcare spending and colorectal cancer death was shown to be independent of country-specific differences in GDP per capita, inflation, interest rates, urbanisation, and nutrition. However, controlling for out-of-pocket spending abolished the association with unemployment, but not government healthcare spending, and subsequent subgroup analysis revealed that the association was no longer significant in those countries that have low levels of OOPE on healthcare.

Strengths and weaknesses of the study

The present study used EU-wide data, taken from high-quality, objective, and centralised databases, avoiding both selection and recall bias. The volume of data used allowed for high statistical powering and multiple robustness checks to be performed, providing confidence in the results obtained. By focussing on the whole of the EU over a 20-year period, this study allows consideration of macroscopic regional trends. In using a panel-data approach to compare unemployment rates or government healthcare spending with mortality rates in each country, we also controlled for time-invariant heterogeneity between countries; something that aggregate, time-series analyses fail to do.

It is important, however, to consider weaknesses of the study. First, public health outcomes and economic trends were examined at the national and international level, without consideration of local discrepancies. Although a number of national studies have been conducted in relation to economic indicators and, for example, colorectal mortality (Lian et al. 2011), our analysis provides important insights across a European population, making it relevant to multinational policy development by agencies such as the IMF, EU, and ECB. We were also unable to model intra-year variations in the level of unemployment or government healthcare spending. The fact that we could not incorporate information regarding the distribution of unemployment throughout different social classes is a second weakness, as economic changes have been shown to impact those of lower SES the most. Similarly, we were

Table 4 Unemployment robustness checks in 27 European Union countries between 1990 and 2009

	Coefficient	Standard error	*P* value	95 % CI (low)	95 % CI (high)
(A) Men					
Controls for economic variables (real interest rate, GDP per capita, inflation)					
Year 0	0.07	0.05	0.14	−0.02	0.17
Year 1	0.13	0.05	0.0095**	0.03	0.22
Year 3	0.17	0.04	0.0001***	0.08	0.25
Year 5	0.14	0.04	0.0002***	0.07	0.21
Controls for nutrition and urbanisation					
Year 0	0.09	0.05	0.0748	−0.01	0.18
Year 1	0.11	0.05	0.0284*	0.01	0.21
Year 3	0.18	0.05	0.0004***	0.08	0.29
Year 5	0.17	0.04	0.0001***	0.08	0.25
Controls for out-of-pocket expenses					
Year 0	−0.02	0.05	0.6603	−0.11	0.07
Year 1	−0.04	0.05	0.4081	−0.15	0.06
Year 3	0.04	0.05	0.4279	−0.06	0.15
Year 5	0.15	0.04	0.0001***	0.08	0.22
(B) Women					
Controls for economic variables (real interest rate, GDP per capita, inflation)					
Year 0	0.09	0.03	0.0050**	0.03	0.16
Year 1	0.11	0.03	0.0009***	0.04	0.17
Year 3	0.11	0.03	0.0001***	0.06	0.16
Year 5	0.08	0.03	0.0082**	0.02	0.13
Controls for nutrition and urbanisation					
Year 0	0.11	0.03	0.0007***	0.05	0.18
Year 1	0.12	0.03	0.0002***	0.06	0.19
Year 3	0.16	0.03	0.0000***	0.10	0.22
Year 5	0.11	0.03	0.0003***	0.05	0.17
Controls for out-of-pocket expenses					
Year 0	−0.01	0.03	0.5876	−0.07	0.04
Year 1	0.05	0.03	0.0991	−0.01	0.11
Year 3	0.12	0.03	0.0009***	0.05	0.18
Year 5	0.10	0.03	0.0001***	0.05	0.15

Increases in colorectal cancer mortality (coefficient) following a 1 % rise in the unemployment rate in years 0, 1, 3 and 5 in men (A) and women (B) are shown. Coefficients, their 95 % confidence intervals, standard errors and the corresponding levels of significance (*P* values) were computed through fixed-effects regression. Controls for economic variables, nutrition and urbanisation are included in the analysis. In all cases, results remain significant

Sources: Colorectal cancer mortality per 100,000—World Health Organisation Mortality Data and Statistics; http://www.who.int/healthinfo/statistics/mortality/en/index.html

Economic and population data: World Bank Development Indicators 2013; http://data.worldbank.org/data-catalog/world-development-indicators

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Table 5 Government healthcare spending robustness checks in 27 European Union countries between 1990 and 2009

	Coefficient	Standard error	*P* value	95 % CI (low)	95 % CI (high)
(A) Men					
Controls for economic variables (real interest rate, GDP per capita, inflation)					
Year 0	−0.44	0.09	0.0000***	−0.62	−0.26
Year 1	−0.30	0.08	0.0001***	−0.46	−0.15
Year 3	−0.27	0.12	0.0219*	−0.51	−0.04
Year 5	−0.07	0.20	0.7370	−0.46	0.32
Controls for nutrition and urbanisation					
Year 0	−0.51	0.11	0.0000***	−0.72	−0.29
Year 1	−0.29	0.11	0.0063**	−0.50	−0.08
Year 3	−0.22	0.13	0.0827	−0.48	0.03
Year 5	−0.14	0.19	0.4582	−0.51	0.23
Controls for out-of-pocket expenses					
Year 0	−0.49	0.09	0.0000***	−0.67	−0.31
Year 1	−0.29	0.09	0.0013**	−0.46	−0.11
Year 3	−0.22	0.11	0.0395*	−0.43	−0.01
Year 5	−0.13	0.13	0.2894	−0.38	0.11
(B) Women					
Controls for economic variables (real interest rate, GDP per capita, inflation)					
Year 0	−0.20	0.06	0.0006***	−0.32	−0.09
Year 1	−0.12	0.06	0.0587	−0.25	0.00
Year 3	−0.11	0.07	0.1127	−0.25	0.03
Year 5	−0.01	0.12	0.9663	−0.24	0.23
Controls for nutrition and urbanisation					
Year 0	−0.31	0.08	0.0001***	−0.47	−0.16
Year 1	−0.24	0.10	0.0154*	−0.43	−0.05
Year 3	−0.22	0.08	0.0087**	−0.39	−0.06
Year 5	−0.09	0.12	0.4686	−0.32	0.15
Controls for out-of-pocket expenses					
Year 0	−0.26	0.07	0.0001***	−0.40	−0.13
Year 1	−0.22	0.08	0.0048**	−0.37	−0.07
Year 3	−0.15	0.06	0.0090**	−0.26	−0.04
Year 5	−0.04	0.09	0.6661	−0.21	0.13

Increases in colorectal cancer mortality (coefficient) following a 1 % rise in government spending on healthcare (% of GDP) in years 0, 1, 3 and 5 in men (A) and women (B) are shown. Coefficients, their 95 % confidence intervals, standard errors and the corresponding levels of significance (*P* values) were computed through fixed-effects regression. Controls for economic variables, nutrition and urbanisation are included in the analysis. In all cases, results remain significant

Sources: Colorectal cancer mortality per 100,000—World Health Organisation Mortality Data and Statistics; http://www.who.int/healthinfo/statistics/mortality/en/index.html

Economic and population data: World Bank Development Indicators 2013; http://data.worldbank.org/data-catalog/world-development-indicators

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Table 6 Subgroup analysis in 19 high and 8 low out-of-pocket expense (OOPE) countries. European Union, 1990–2009

	Coefficient	Standard error	*P* value	95 % CI (low)	95 % CI (high)
(A) Men					
Countries with out-of-pocket expenses above 13.9 % ($n = 19$)					
Unemployment and colorectal cancer mortality	0.23	0.07	0.0011**	0.09	0.37
Government spending on healthcare and colorectal cancer mortality	0.00	0.62	0.9964	−1.23	1.22
Countries with out-of-pocket expenses below 13.9 % ($n = 8$)					
Unemployment and colorectal cancer mortality	0.03	0.05	0.5755	−0.08	0.14
Government spending on healthcare and colorectal cancer mortality	0.40	0.30	0.2162	−0.27	1.07
(B) Women					
Countries with out-of-pocket expenses above 13.9 % ($n = 19$)					
Unemployment and colorectal cancer mortality	0.11	0.06	0.0897	−0.02	0.23
Government spending on healthcare and colorectal cancer mortality	−0.62	0.24	0.0104*	−1.09	−0.15
Countries with out-of-pocket expenses below 13.9 % ($n = 8$)					
Unemployment and colorectal cancer mortality	−0.02	0.03	0.4593	−0.08	0.04
Government spending on healthcare and colorectal cancer mortality	0.02	0.19	0.9360	−0.41	0.44

A 13.9 % threshold was employed to divide countries into high and low OOPE groups. Increases in colorectal cancer mortality (coefficient) following a 1 % rise in either the unemployment rate or in government spending on healthcare (% of GDP) in men (A) and women (B) are shown. Coefficients, their 95 % confidence intervals, standard errors and the corresponding levels of significance (*P* values) were computed through fixed-effects regression. For countries with below-threshold OOPE, the relationship between unemployment and colorectal cancer mortality and government healthcare spending and colorectal cancer mortality is no longer statistically significant. However, the relationship remains statistically significant in those countries with above-threshold OOPE for men (unemployment) and government healthcare spending (women)

Sources: Colorectal cancer mortality per 100,000—World Health Organisation Mortality Data and Statistics; http://www.who.int/healthinfo/statistics/mortality/en/index.html

Economic and population data: World Bank Development Indicators 2013; http://data.worldbank.org/data-catalog/world-development-indicators

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

unable to determine whether changes to government healthcare spending were matched with increasing efficiency; were this the case, reductions in overall healthcare spending could feasibly co-exist with maintained colorectal cancer mortality rates. Third, whilst a number of controls were included in robustness checks, healthcare factors—such as access to primary care or screening programmes—were not incorporated into the regression models. Additionally, we accept that this study does not suggest causality, merely an association, and as such there are possible a number of possible confounding factors which could theoretically explain the reported increase in colorectal cancer mortality. The observed effect may reflect a true increase in incidence, or an increase in diagnosis. Whilst a number of Western European countries have reported stable colorectal cancer incidence over the last four to five decades (Center et al. 2009), there is an inconsistent picture across the EU and changes to incidence could potentially confound results. Alternative confounders include coincidental worsening of clinical care or a change in colorectal cancer prognosis towards mortality. However, there is no evidence for the existence of these phenomena, and recent literature suggests that both clinical care and colorectal cancer prognosis continue to improve (Golan et al. 2013).

Findings in relation to existing literature

The association between low SES and increased colorectal cancer mortality is widely described in the literature (Du et al. 2007). However, very few studies provide in-depth analysis of the contribution of unemployment and public healthcare spending to this association and an analysis of the effect of government healthcare spending on colorectal cancer is lacking. In those studies that have looked specifically at unemployment and mortality at the individual level, there is a strong, positive association (Morris et al. 1994). Whilst few studies have looked at cancer deaths (Morris et al. 1994), the effect of unemployment and government healthcare spending on specific tumour types has not previously been examined. Similarly, studies have shown an association between reduced government healthcare spending and increased mortality in a number of settings (Shi 1995), with one paper looking specifically at country-specific differences in breast cancer mortality in the EU (Ades et al. 2013). However, in general there is a

lack of work analysing the effect of changes in healthcare spending on individual diseases, and so far there have been no studies investigating colorectal cancer mortality.

Therefore, a major strength of this study is that we have provided evidence for an association between two important health-economic indicators—unemployment and government spending on healthcare—and a specific disease. This is a novel and unique approach; building on and expanding previously published literature.

Implications for clinicians and policymakers

The mechanism by which rises in unemployment and public healthcare spending affect colorectal cancer mortality is poorly understood. One possibility is that the psychological stress of unemployment can directly influence disease incidence and the biological mechanisms underlying this process are under active investigation (McEwen and Tucker 2011). Dietary factors are known to have an impact on risk of colorectal cancer and it is feasible that nutritional factors could play a part. However, when mean calorie intake was controlled for in our model, an association was still observed, implying that this is not a major mechanism, consistent with previous studies (Lian et al. 2011). Additionally, commentators have suggested that comorbid illness, known to impact colorectal cancer survival (De Marco et al. 2000), and lifestyle factors—such as tobacco and alcohol consumption—are largely to blame for increased mortality in patients of lower SES (Frederiksen et al. 2009). However, evidence on this association is inconsistent as a statistically significant higher risk of death in the unemployed has been observed even when social class, smoking, alcohol consumption, and body weight are controlled for (Morris et al. 1994). This is consistent with our own findings of an association, even when nutrition and economic factors are controlled for.

Screening programmes, faster time to diagnosis and rapid progression to treatment have all been shown to reduce colorectal cancer mortality (Hardcastle et al. 1996). Therefore, reduced access to, or utilisation of, such healthcare services would logically increase mortality rates. Both unemployment and reduced government healthcare spending have been shown to adversely affect access to healthcare (Palmer et al. 2004) and it is well documented that individuals from high poverty areas have substantially higher rates of late-stage cancer diagnosis and reduced compliance with screening programmes (Singh et al. 2003). Our data, which shows the strongest and largest association between unemployment and increased colorectal cancer mortality in years three to four (Table 2) following an unemployment rise would support this mechanism, in line with existing literature which shows a lag in the benefit of colorectal cancer screening (Lee et al. 2013). Additionally, when OOPE on healthcare—a barrier to access to healthcare in the EU (Lostao et al. 2007)—is controlled for, the association is no longer statistically significant, especially in those countries where OOPE on healthcare is less than 13.9 % of total healthcare expenditure. Taken together, this suggests that a major mechanism by which unemployment and reduced government healthcare spending affects colorectal cancer mortality is by reducing access to healthcare services.

In addition to reduced access to care, it is also possible that reduced utilisation of care may play an important role. Much work has been done on models of healthcare utilisation (Andersen 1995, 2008) and a number of factors, including a patient's health beliefs, social support structure and perceived need of healthcare are felt to be instrumental (Hulka and Wheat 1985; Portes et al. 1992). It is not inconceivable that following unemployment, the ensuing social isolation and a perceived relative unimportance of health problems lead to reduced healthcare usage.

A cross-sectional examination of provision of colorectal screening programmes in relation to unemployment rates and healthcare expenditures reveals no clear trend. For example in 2007 the eight EU countries with no screening programme had a wide variety of healthcare expenditures (Supplementary Table 1). The EU country with the lowest healthcare expenditure (Cyprus) had a colorectal cancer screening programme, whilst Denmark—the country with the second highest healthcare expenditure—did not have a programme. This data would appear to corroborate the suggestion that it is reduced access to and utilisation of healthcare, rather than provision, which may underpin the observed associations between unemployment/healthcare expenditure and colorectal cancer mortality.

Our work adds to a substantial body of literature that suggests that policies leading to unemployment and reduced government healthcare spending may result in significant public health harm (Kentikelenis et al. 2011; Thomson et al. 2013), highlighting specific additional problems that unemployment and reduced government spending on healthcare bring. Our results also demonstrate that macro-level multinational policy can impact mortality at the individual level. Clinicians should be aware of the potential ramifications of policy changes and their mechanisms, taking action—such as facilitating access to healthcare and promoting engagement with healthcare services and screening programmes—during periods of reduced public-sector healthcare spending to mitigate adverse effects (Maclennan and Hill 1993). Recently implemented fiscal consolidation measures, which have been associated with reduced healthcare spending (Keegan et al. 2013), are likely exacerbating the adverse health effects of the global economic downturn rather than ameliorating them. Changes to healthcare services which

extend co-payment systems—such as those recently implemented in Spain (Garcia Rada 2012)—are likely to be particularly damaging. Our work, demonstrating the negative impact of OOPE on healthcare, is in line with a recent WHO report commenting that healthcare systems with low levels of OOPE perform better during times of fiscal pressure (Thomson et al. 2013). As such, caution must be taken in debates concerning cost control and budget restrictions of healthcare. If cost reductions are not achieved as a result of efficiency improvements, they may entail worse quality care and in turn greater mortality. Conversely, policies that support re-employment, prevent further job losses or increase government healthcare spending may have tangible benefits in terms of cancer survival. Indeed, there is a strong case for supporting, promoting and expanding the use of primary prevention programmes, which, although expensive, represent significant value and may be particularly important at times of financial constraint (Martin-Moreno et al. 2012).

Conclusions

Our study has shown that increased unemployment is associated with increased colorectal cancer mortality rates in the EU. A likely mechanism for these associations is the reduction in access to care that can occur during times of high unemployment. We also found that increased government expenditure on healthcare is associated with reduced colorectal cancer mortality rates. These findings are important for clinicians and policy makers alike. Clinicians need to facilitate access to care for the unemployed and policy makers should seek to protect healthcare expenditure to maintain or improve colorectal cancer outcomes.

Compliance with ethical standards

Ethical approval No ethical approval was required for this study.

Conflict of interest The authors declare that there are no competing interests.

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