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Exploring the relationship between primary care expenditure, outcomes and overall NHS expenditure

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Abstract

Little is known about the relationship between primary and secondary care expenditure, and the existing literature suggests mixed evidence on the effect of increasing primary care expenditure on population health. This paper examines the impact of longitudinal variations between 2006 and 2009 in primary care expenditure by Primary Care Trusts (PCTs) on population health and secondary care expenditure. Our measures of primary care expenditure are the number of GPs and the level of primary care prescribing costs. Population health is measured by rates of overall mortality, child mortality and deaths amenable to health care. Secondary care expenditure is measured by emergency admissions for conditions usually managed in primary care and total expenditure. The availability of longitudinal data allows us to use a fixed effects estimation method, controlling for time-invariant PCT characteristics that may be correlated with our dependent and explanatory variables. We find that increases in primary care expenditure, whether through increasing the number of GPs or the cost of prescribing, is associated with reductions in all measures of mortality. However, it is also associated with increases in secondary care expenditure. A one unit increase in the number of GPs is associated with a reduction of 0.241 deaths amenable to health care and an increase in secondary care expenditure of £18.58 per capita. An increase of £10 per capita on prescribing expenditure is associated with a reduction of 0.071 deaths amenable to health care and an increase in secondary care expenditure of £17.81 per capita. Our results suggest that increases in primary care expenditure do have positive effects on population health but are also associated with higher secondary care expenditure. These results raise questions on the cost-effectiveness of increasing primary care expenditure.

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Introduction

There are few studies investigating the effect of primary medical care expenditure on population health and secondary care expenditure. Of the studies that have been undertaken, much of the evidence is from outside of England and overall it provides mixed results. In this paper we have created a panel of Primary Care Trust (PCT) level statistics over the period of 2006 to 2009 to relate changes in the number of GPs and prescribing expenditure to changes in three measures of mortality and three measures of secondary care activity. Primary Care Trusts (replaced by Clinical Commissioning Groups in April 2013) were the bodies responsible for commissioning NHS services in a certain geographical area, holding roughly 80% of the total NHS budget.

Of the studies that have attempted to estimate the effect of primary medical care input on population health, the most comprehensive cross-national study by Macinko, Shi and Starfield (2003) used annual data for 18 countries over a period of 28 years (1970 to 1998) and showed that the strength of a country's primary care system was negatively associated with all-cause mortality, all-cause premature mortality, and cause-specific premature mortality from asthma and bronchitis, emphysema and pneumonia, cardiovascular disease, and heart disease. Aakvik and Holmas (2006) using data at municipality level over 15 years (1989 to 2001) analysed the effect of access to primary care (proxied by the number of GPs) on health outcomes in Norway. They found no effect on mortality of the volume of GP supply but an effect of composition, with more contracted GPs reducing mortality.

In England, Gulliford (2002) used cross-sectional data from 1999 for 99 health authorities and showed that numbers of GPs per capita were negatively correlated with population mortality rates and hospital admissions due to acute and chronic conditions. Gravelle, Morris and Sutton (2008) used individual level data on health from three waves of the Health Survey for England (1998, 1999 and 2000) and Local Authority level data on GPs per capita. After allowing for the endogeneity of GP supply through the use of instrumental variables, they found that an increase in GP supply had a significant positive effect on self-reported individual health. An increase in GPs per capita of 10 percent was associated with an improvement in health of between 0.4 and 2.4 percent depending on the estimation model used. Using the same dataset and a similar technique, Gravelle and Morris (2008) showed that GP supply had a negative effect on obesity.

One of the aims of this paper is to calculate the cost of a life saved through primary care expenditure. Claxton et al (2013) have estimated the cost to the NHS as a whole per death averted to be between £200,829 and £653,748.

This literature suggests mixed evidence on the effect of greater GP supply on population health. We seek to update this evidence and tailor it to the current English context using the most recent available data and panel data regression methods. The use of panel regression methods allows us to control for unmeasured factors at PCT level, for example population characteristics such as the prevalence of heavy drinking, smoking, deprivation and the age distribution of individuals within a PCT. These unobserved factors are most likely correlated with the explanatory variables and unless controlled for will lead to a bias in our estimates. In addition, we examine the effect of primary care spending on secondary care expenditure. It has long been believed that moving activity from a secondary care setting to general practice or the community would be associated with overall reductions in health service costs. Some examples of specific forms of these initiatives are minor surgery, chronic disease management, GPs With a Special Interest and follow-ups in primary care after hospital discharge (Roland et al 2006) and, although various studies have assessed the impact on improving quality in primary care, few have assessed the overall costs to the NHS of increased primary care spending.

Methods

Data

To examine the impact of variations in primary medical care/general practice expenditure between Primary Care Trusts over time we have used published data to create a short longitudinal data set. We collated readily-available data published by the NHS Information Centre and the Department of Health on PCT primary and secondary care expenditure, numbers of general practitioners, population health indicators and numbers of, and expenditure on, hospital admissions. Table 1 shows the summary statistics for the collated data split by each year.

To examine the effect that changes in primary care expenditure and the supply of primary care providers has on population health we obtained data on three population health indicators at PCT level. These indicators are indexes measuring the number of deaths amenable to health care, total mortality (deaths of those <75) and child mortality (deaths of those <15). The measure of deaths amenable to health care includes causes of death where there is evidence that they are preventable given timely, appropriate, and high quality care these causes of death include, measles (ages 1-14 years), Asthma (ages 0-44 years) and Appendicitis (ages 0-74 years). See the appendix for the full list of causes of death which are considered to be amenable to health care.

One of the potential pathways that a change in PCT expenditure on primary medical care services may affect total NHS expenditure is through a reduction in hospital admissions for conditions normally dealt with by primary care providers. To examine the strength of this association we have obtained measures of emergency hospital admissions for chronic and acute conditions normally managed in primary care. The hospital admission indicators measure the number of finished and unfinished continuous inpatient spells, excluding transfers, for patients with an emergency method of admission with any of the following primary diagnoses: asthma, diabetes, ear, nose, throat, kidney and urinary tract infections and heart failure. For further information on the conditions included in these measures see the appendix.

Data on PCT spending on primary and secondary care were taken from the Department of Health's Programme Budgeting report and is available for the tax years 2003/04 until 2010/11. However, before the tax year 2006/07 spending was not separated into spending on primary and secondary care and, due to a change in expenditure calculations, the 2010/11 data are not comparable with previous years. The Programme Budgeting report seeks to allocate all types of PCT expenditure to primary care and secondary care over 23 categories. Of these 23 categories, 22 measure PCT spending on groups of conditions such as, infectious diseases, cancer and tumours, and mental health disorders. These categories do not take into account expenditure on disease prevention or primary care practitioners

(GPs) but do include prescribing expenditure. The 23rd category is classed as 'other' and includes all PCT spending on General Medical Services contracts and Personal Medical Services contracts. Using these data we are able to examine the effects of PCT spending on prescribing and the supply of GPs separately.

Analysis

To allow for the endogeneity of GP supply, we used fixed effects regression. This approach controls for differences in the level of GP supply between PCTs that may be correlated with population health and secondary care expenditure (plausibly due to planning processes that might lead to more GPs in areas that need them most or preferences of GPs to locate in desirable areas where they are needed least), and changes in GP supply and outcomes over time that may confound the desired relationship. A fixed effects model allows us to generate parameter estimates that control for time-invariant differences between PCTs and general trends over time. The use of fixed effects regression analyses also allows us to control for PCT characteristics correlated with population health, hospital admissions or secondary care costs which we have omitted from our model.

We assume that this unmeasured heterogeneity shifts the regression line up or down by a fixed amount for each PCT so that:

$$y_{it} = a + bX_{it} + d_i + p_t + u_{it}$$

where y_{it} is one of the dependent variables of interest (population health, emergency hospital admissions or secondary care costs), X comprises the time-varying regressors measuring GP supply and primary care prescribing expenditure, d_i is the unobserved fixed effect for each PCT, p_t are year dummies, and u_{it} is a random error term.

We assume that PCTs can allocate their primary care budget between prescribing costs or the supply of primary care practitioners (GPs). Our regression models therefore include the total number of GPs practising within a PCT and PCTs' total prescribing expenditure as independent variables. In further analysis we estimate the effect of including only one of these variables.

We can use the results from our regression analyses to estimate the cost of preventing deaths by increasing either GP labour supply or PCT spending on primary care prescribing. We use the formula:

$$(C_1+C_2)/D$$

where C_1 is the cost of increasing GP labour supply or primary care prescribing, C_2 is the change in secondary care costs associated with the increased expenditure on primary care and D is the change in the number of deaths.

Results

After undertaking a range of specification tests to assess whether the effects of changes in primary care input were best captured by a linear or logged relationship we found there was no clear evidence in favour of either specification. We present results from models with a linear specification.

The results of the fixed effects regression analyses of the effects of General Practitioner supply and prescribing expenditure on population health are shown in table 2. The coefficients on the year dummies are negative and significant suggesting that amenable death, child mortality and total mortality rates decreased each year between 2006 and 2009. The coefficients on the independent variables for GP supply (GPs per 100,000 PCT population) and primary care expenditure on prescribing (£10 spent per capita) are all negative, suggesting that increases in either of these variables leads to a decrease in population mortality larger than the national trend. Increasing the number of GPs per 100,000 population by 1 will reduce the amenable death, child mortality and total mortality rates by 0.241, 0.022 and 0.335 per 100,000 population respectively. Increasing the amount spent on primary care prescribing by £10 per head will lead to a decrease in the rates of deaths amenable to health care, child mortality and total mortality by 0.035, 0.014 and 0.071 per 100,000 population respectively. The results show that both GP supply and PCT prescribing expenditure have statistically significant effects on deaths amenable to health care and that the level of PCT prescribing expenditure also has a statistically significant effect on total mortality rates.

The results from the fixed effects regression analyses examining the impact of GP supply and primary care prescribing expenditure on hospital admissions and secondary care costs are presented in table 3. The regression analyses suggest that the rate of emergency hospital admissions for acute conditions normally managed in primary care was significantly larger in 2008 and 2009 compared to 2006 whilst the rate of emergency hospital admissions due to chronic conditions normally managed in primary care was significantly less in 2007 and 2009 than in 2006. An increase in GP supply of 1 per 100,000 population leads to a decrease in the rate of emergency admissions per 100,000 population due to acute and chronic conditions by 1.049 and 0.837 respectively. Increasing primary care prescribing expenditure by £10 per head leads to an increase in the rate of emergency hospital admissions due to acute conditions by 0.064 per 100,000 population and a decrease in admissions due to chronic conditions by 0.028 per 100,000 population. However, the effects of GP supply and prescribing expenditure on these rates of emergency hospital admissions are not statistically significant at the 5% level.

Secondary care expenditure is significantly higher in 2007, 2008 and 2009 than in 2006. The coefficients on the variables for GP supply and prescribing expenditure suggest that GP supply and primary care prescribing expenditure both have a statistically significant positive impact on secondary care expenditure. Increasing the number of GPs by 1 per 100,000 population and prescribing expenditure by £10 per head leads to an increase in secondary care costs per person of £18.58 and £17.81 respectively.

The previous models assume that the impact of changes in primary care input on health and secondary care activity are instantaneous. It is plausible that it may take time for investments in primary care to have an impact. The results of one-year lagged GP supply and primary care prescribing expenditure on secondary care costs are presented in table 4. The results show that increases in GP supply and primary care prescribing expenditure reduce secondary care costs in the following year. Increasing GP supply by 1 per 100,000 population and prescribing expenditure by £10 per head leads to a decrease in next year's secondary care costs per capita by £2.874 and £3.55 respectively. However, only the coefficient on the lagged primary care prescribing expenditure variable is statistically significant at 5%.

The measures of primary care input we have included as independent variables in our regression analyses are likely to be positively correlated making it difficult to separate their effects empirically. As a sensitivity check we therefore drop each of the primary care variables in turn and show the results using each variable individually.

Tables 5 and 6 show the results of single variable fixed effect regression models of GP labour supply, prescribing expenditure, lagged GP supply and lagged prescribing expenditure on the six dependent variables of interest. The coefficients on the variables measuring GP supply and prescribing expenditure are similar to the models including both variables. Lagged GP labour supply has an insignificant positive effect on the amenable death rate and total mortality rate, and an insignificant negative effect on emergency hospital admissions due to chronic and acute conditions and secondary care expenditure. The results of the models which included lagged primary care prescribing expenditure as an explanatory variable suggest that it has a negative effect on amenable death rate, child mortality, total mortality and secondary care expenditure whilst having a positive effect on the rate of emergency hospital admissions due to chronic and acute conditions normally handled in primary care, although none of these results are significant at the 5% confidence level.

The results of our regression analyses reported in tables 2 and 3 suggest that an increase in the number of GPs of 1 per 100,000 capita will reduce the amenable death rate per 100,000 by 0.24 with an associated increase in secondary care costs of £18.58 per person. We can calculate the cost of preventing an amenable death using the formula $(C_1+C_2)/D$. We assume a hypothetical PCT which serves a population of 400,000. To increase the number of GPs within this PCT by 1 per 100,000 registered population the PCT will need to employ 4 new GPs and incur a direct cost of £978,400 (using average GMS contract costs from the 2010/11 GP earnings and expenses enquiry) and an indirect cost of £7,432,000 due to increased secondary care expenditure. This increase in GP supply will lower the number of amenable deaths for the PCT by 0.964. The cost of reducing the number of amenable deaths by one through increasing GP supply equals £8,724,000. We compare this cost to the cost of preventing an amenable death through increasing expenditure on primary care prescribing. Increasing primary care prescribing expenditure by £10 per head leads to a decrease in the amenable death rate of 0.035 per 100,000 and an increase in secondary care costs per person of £17.81. An increase in primary care prescribing expenditure of £10 per head for our hypothetical PCT with a registered population of 400,000 will lead to a direct cost of £4,000,000 and indirect secondary care cost of £7,124,800, this expenditure on primary care prescribing will reduce the number of amenable deaths by 0.14. The total cost for the PCT to prevent an amenable death through prescribing expenditure alone is £79,462,857.

Discussion

Using fixed effects regression methods to control for differences between PCTs and general trends over time we investigated how levels of primary care inputs affect population health and expenditure on secondary care. Our multivariate regression analyses show that increasing PCT spending on GP labour supply and primary care prescribing expenditure is associated with a decrease in all measures of death rates. The supply of GPs has a significant negative effect on deaths amenable to health care and primary care prescribing expenditure has a significant effect on deaths amenable to health care and total mortality in models.

One pathway by which PCT expenditure may have an effect on secondary care costs is through reduced emergency hospital admissions for conditions normally dealt with by primary care providers. However, increases in the supply of GPs or prescribing expenditure were not found to have a significant effect on emergency hospital admissions for chronic or acute conditions and were found to have a significant positive effect on overall secondary care costs. One possible reason for this may be that increasing the supply of GPs leads to increased secondary care referrals and warrants further study. We investigated the possibility of PCT expenditure on primary care having a future effect on secondary care costs by regressing the lagged values of GP supply and prescribing expenditure on current secondary care costs. These results suggest that increasing GP supply and primary care prescribing may have a negative effect on secondary care costs one year later, but only the coefficient on primary care prescribing expenditure was statistically significant. Our assumption that increased primary care expenditure affects secondary care costs after only one year may be too optimistic and further work is needed to investigate how long the time lag on cost savings may be.

We calculated the costs to a PCT to prevent a death amenable to health care through either increasing primary care prescribing expenditure or GP supply. Our results showed that a PCT would be better to increase expenditure on GP supply, but the cost per death averted is still very high because of the associated increase in secondary care costs. There may be other benefits of increasing primary care expenditure (including an effect on quality of life rather than mortality) an alternative strategy and possible future research would be to use panel data techniques and assess the impact of GP supply on a measure of quality of life such as the EQ-5D used by Gravelle et al (2008). Our method of calculation of the costs to a PCT to prevent a death amenable to health care assumes that the effect of changes in GP supply or primary care prescribing on mortality and secondary care expenditure is restricted to one time period. In reality this may not be the case, and an increase in GP supply or prescribing expenditure that reduces mortality in one year may well reduce mortality in years to follow. If this is the case than our estimate of the cost of a life saved will be overestimated.

In conclusion, the availability of repeated observations through time for each PCT allowed us to use fixed effects regression methods to control for factors within a PCT which may confound a simple cross-sectional analysis. This is a major strength of our study. To our knowledge no other study has used panel data techniques to assess the effects of GP supply on mortality in an English setting. Although we find increases in PCTs' spending on primary care services to have the desired effect of reducing population mortality, the associated increase in secondary care expenditure does not make this a cost effective way to reduce mortality.

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Table 1 Descriptive statistics

Variable	2006	2007	2008	2009
General Practitioners per 100,000 population				
Observations	152	152	152	152
Mean	65.01	65.3	66.26	69.58
Minimum - Maximum	44.50 – 99.90	48.29 – 90.83	47.27 – 91.86	53.75 – 99.08
Amenable Death Rate per 100,000 population				
Observations	151	151	151	151
Mean	112.68	106.95	103.52	96.73
Minimum - Maximum	63.41 - 177.79	66.24 - 164.74	64.32 - 166.34	62.83 - 159.32
Total Mortality Rate per 100,000 population				
Observations	151	151	151	151
Mean	613.09	599.47	595	566
Minimum - Maximum	364.42 - 813.42	373.55 - 776.10	364.35 - 791.06	354.76 - 766.37
Child Mortality Rate per 100,000 population <15years				
Observations	151	151	151	151
Mean	52.49	49.74	47.24	46.26
Minimum – Maximum	16.89 - 94.59	21.46 - 121.63	14.03 - 95.58	15.76 - 92.84
Prescribing Expenditure per capita				
Observations	145	142	140	149
Mean (£)	285.04	288.61	557.55	460.88
Minimum - Maximum (£)	63.37 – 915.50	39.61 – 1455.77	33.98 – 2609.57	37.80 – 1879.12
Secondary Care Expenditure per capita				
Observations	151	151	152	152
Mean (£)	933.39	1112.06	1764.43	1525.12
Minimum - Maximum (£)	169.29 – 3839.78	145.28 – 3085.76	150.41 – 6931.26	149.40 – 5659.66

Table 2 Regressions using health variables

Variable	Amenable deaths	Child mortality	Mortality
Year (2006 reference)			
2007	-6.072*** (-7.57)	-2.984* (-2.22)	-14.712*** (-7.83)
2008	-7.995*** (-9.15)	-4.805** (-3.16)	-16.346*** (-8.01)
2009	-14.456*** (-16.85)	-5.856*** (-3.52)	-45.212*** (-19.37)
GPs per 100,000 population	-0.241* (-2.34)	-0.022 (-0.14)	-0.335 (-1.23)
Primary care prescribing expenditure (£10 per capita)	-0.035* (-2.31)	-0.014 (-0.52)	-0.071* (-2.62)
Constant	129.603*** (19.20)	54.251*** (5.38)	637.731*** (35.43)

Notes: * p<0.05, ** p<0.01, *** p<0.001 t-ratios in parentheses.

Table 3 Regressions for secondary care activity and expenditure

Variable	Acute Conditions	Chronic conditions	Secondary care expenditure
Year (2006 reference)			
2007	2.224 (0.45)	-13.170*** (-6.44)	201.873*** (3.91)
2008	18.132** (2.67)	-0.825 (-0.28)	316.719*** (6.04)
2009	25.146** (3.52)	-6.457* (-2.03)	223.277*** (3.92)
GPs per 100,000 population	-1.049 (-0.95)	-0.837 (-1.71)	18.582* (2.97)
Primary care prescribing expenditure (£10 per capita)	0.064 (0.60)	-0.028 (-0.63)	17.812*** (14.74)
Constant	520.632*** (7.08)	256.364*** (7.84)	-817.302 (-1.98)

Notes: * p<0.05, ** p<0.01, *** p<0.001 t-ratios in parentheses.

Table 4 Regression for secondary care expenditure on lagged primary care input variables

Variable	Secondary care expenditure (per capita)
Year (2007 reference)	
2008	665.975*** (8.10)
2009	538.553*** (6.09)
Lagged GPs per 100,000 population	-2.874 (-0.15)
Lagged primary care prescribing expenditure (£10 per capita)	-3.546* (-1.96)
Constant	1358.941 (1.11)

Notes: * p<0.05, ** p<0.01, *** p<0.001 t-ratios in parentheses.

Table 5 Regression models for population health with single measures of primary care input

Variable	Amenable Deaths	Child Mortality	All Mortality
GPs per 100,000 population	-0.249* (-2,35)	-0.041 (-0.27)	-0.363 (-1.29)
Primary care prescribing expenditure (£10 per capita)	-0.036* (-2.40)	-0.015 (-0.56)	-0.070* (-2.58)
Lagged GPs per 100,000 population	0.174 (0.83)	-0.016 (-0.05)	0.442 (0.88)
Lagged primary care prescribing expenditure (£10 per capita)	-0.005 (-0.26)	-0.016 (-0.31)	-0.015 (-0.28)

Notes: * p<0.05, ** p<0.01, *** p<0.001 t-ratios in parentheses.

Table 6 Regression models for secondary care expenditure, with single measures of primary care expenditure

Variable	**Acute Conditions**	**Chronic Conditions**	**Secondary Care Expenditure (per capita)**
GPs per 100,000 population	-0.851 (-0.79)	-0.784 (-1.62)	20.732* (2.02)
Primary care prescribing expenditure (£10 per capita)	0.058 (0.53)	-0.034 (-0.75)	17.822*** (14.21)
Lagged GPs per 100,000 population	-1.241 (-0.97)	-0.563 (-0.88)	-6.973 (-0.41)
Lagged primary care prescribing expenditure (£10 per capita)	0.030 (0.26)	0.090 (1.59)	-3.457 (-1.98)

Notes: * p<0.05, ** p<0.01, *** p<0.001 t-ratios in parentheses.

Appendix

Causes of Death Considered Amenable to Health Care

- Intestinal infections (ages 0-14 years)
- Tuberculosis (ages 0-74 years)
- Other infectious diseases (diptheria, tetanus, poliomyelitis) (ages 0-74 years)
- Whooping cough (ages 0-14 years)
- Septicaemia (ages 0-74 years)
- Measles (ages 1-14 years)
- Malignant neoplasm of colon and rectum (ages 0-74 years)
- Malignant neoplasm of skin (ages 0-74 years)
- Malignant neoplasm of female breast (ages 0-74 years)
- Malignant neoplasm of cervix uteri (ages 0-74 years)
- Malignant neoplasm of unspecified part, or body, of the uterus (ages 0-44 years)
- Malignant neoplasm of testis (0-74 years)
- Hodgkin's disease (ages 0-74 years)
- Leukaemia (ages 0-44 years)
- Diseases of the thyroid (ages 0-74 years)
- Diabetes mellitus (ages 0-49 years)
- Epilepsy (0-74 years)
- Chronic rheumatic heart disease (ages 0-74 years)
- Hypertensive disease (ages 0-74 years)
- Ischaemic heart disease (ages 0-74 years)
- Cerebrovascular disease (ages 0-74 years)
- All respiratory diseases (excl. pneumonia, influenza and asthma) (ages 1-14 years)
- Influenza (ages 0-74 years)
- Pneumonia (ages 0-74 years)
- Asthma (ages 0-44 years)
- Peptic ulcer (ages 0-74 years)
- Appendicitis (ages 0-74 years)
- Abdominal hernia (ages 0-74 years)
- Cholelithiasis & cholecystitis (ages 0-74 years)
- Nephritis and nephrosis (ages 0-74 years)
- Benign prostatic hyperplasia (ages 0-74 years)
- Maternal deaths (ages 0-74 years)
- Congenital cardiovascular anomalies (ages 0-74 years)
- Perinatal deaths (all causes excl. stillbirths), ages 0-6 days)
- Misadventures to patients during surgical and medical care (ages 0-74 years)

Emergency Hospital Admission Conditions

Chronic conditions

Asthma

- Asthma;
- Status asthmaticus

Diabetes

- Insulin-dependent diabetes mellitus;
- Non-insulin-dependent diabetes mellitus;
- Malnutrition-related diabetes mellitus;
- Other specified diabetes mellitus;
- Unspecified diabetes mellitus.

Acute conditions

Ear, nose and throat infections

- Suppurative and unspecified otitis media;
- Acute pharyngitis;
- Acute tonsillitis;
- laryngitis;
- Acute upper respiratory infections of multiple and unspecified sites;
- Chronic rhinitis, nasopharyngitis and pharyngitis.

Kidney / urinary tract infections

- Renal tubulo-interstitial disease, unspecified;
- Urinary tract infection, site not specified;
- Acute cystitis.

Heart failure

- Heart failure
- Hypertensive heart disease