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Financial risk in commissioning: cancer costs

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Abstract

The financial risk and volatility in costs associated with cancer commissioning is very high. Depending on location, commissioning groups with an anticipated £10 million cancer spend can experience anywhere between 10% to 50% average year-to-year volatility in costs. Due to the effect of size the range associated with this risk drops to 3.2% to 15.8% for a cancer budget of £100 million, equivalent to the largest PCT populations (i.e. Hampshire, Leeds, Norfolk, etc). The wide range arises from the location-specific (environmental) nature of risk. Particular high volume cancers (rectum, colon, breast, etc), exhibit high volatility due to special sensitivity to the environment and show cyclic behaviour over extended time periods. The financial risk in cancer commissioning therefore involves a high degree of complex spatio-temporal trends which are reminiscent of infectious outbreaks. Especially high volatility in the costs for 'miscellaneous' cancers suggest they should be commissioned as part of wider regional risk pools.

Key Points

- The financial risk in cancer commissioning is very high and shows evidence for spatio-temporal trends; hence, some commissioners (locations) experience considerably higher unavoidable volatility in costs than others.
- This high volatility places a strain on the rest of the health care budget and makes financial planning and achieving break-even a difficult task due to the high level of uncontrollable variation.
- The financial risk inherent in aspects of cancer care may require regional or national level risk pools to avoid the inevitable outcome of a postcode lottery.
- Infectious outbreaks appear to regulate some of this behaviour.

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Introduction

The advent of GP commissioning and the formation of clinical commissioning groups has focussed attention on the components of health care costs and the volatility associated with these costs. The ability to forecast future expenditure and hence financial planning relies on the assumption that costs are relatively stable with respect to the forecast average. However is this assumption valid and could it be that the perceived poor performance of the former Primary Care Trusts (PCTs) may have arisen out of higher intrinsic volatility in health care costs than has previously been acknowledged?

Between 2003/04 and 2010/11 PCTs in England collectively spent an average of 6.2% (range 6.1% to 6.4%) of their total budget on cancer care. According to the Programme Budget costs submitted by PCTs for 2010/11 this amounted to £5.6 billion of expenditure or around £110 for every adult and child in England. Of the total in 2008 it is estimated that the cost of care delivered to patients dying with cancer (27% of total deaths) was £1.8 billion (NAO 2008) and it has also been estimated that 3% of cancer survivors remain as high service users (Maddams et al 2011). In the US, childhood cancer incidence has increased significantly since 1997 with the majority being leukemias, rates are highest in inner city locations and cost per hospital admission are 5-times higher and death in hospital is 10-times higher than for other paediatric non-cancer admissions (Anhang Price et al 2012b).
Given that cancer care accounts for such an important part of total costs we should be seeking to understand the volatility in costs associated with this important component of health care expenditure.

Cancer care represents a special case in that, somewhat similar to long term conditions, the point of initial diagnosis initiates a cascade of costs associated with multiple outpatient, inpatient, A&E attendances, ambulance transport and even palliative admissions depending on the patient and their particular circumstances. At small area level this generates very high granularity as the cumulative costs are localised (where the patient lives) or to a GP practice (where the costs accrue). Depending on the set of environmental conditions which may act as risk factors to developing cancer, act to speed its growth or may exacerbate symptoms to the point where the person seeks a diagnosis additional long term patterns may also exist and will also act to generate further volatility in costs. Volatility will also be expected to increase as the population covered by a CCG becomes smaller and some form of risk sharing will become increasingly important. The key point is that if cancer care is associated with high volatility in costs then this will create pressures in an otherwise fixed total budget and financial planning and management are made more complex.

This paper will investigate the year-to-year volatility associated with a time series of cancer costs collected at PCT level in England. Data covering a wider spectrum of cancer types from the USA will also be used to investigate the extent of volatility and to consider if longer-term patterns in cost and incidence also exist for particular cancer types.

Methods

PCT level costs for cancer between 2003/04 and 2010/11 were extracted from the 'Programme Budgeting' pages of the Department of Health website (http://www.dh.gov.uk/en/Managingyourorganisation/Financeandplanning/Programmebudgeting/DH_075743#_1). Total cancer costs were available for the entire period while costs for different cancer groups were available for 2006/07 to 2010/11. The absolute value of growth-adjusted year-to-year volatility in costs was calculated as a percentage: [Year (n+1) – Year (n) – Slope]/Year (n) and was then averaged over the time period. The slope of the trend over time was determined by linear regression. The data was corrected for a minority of errors (less than 0.5% of the total data values) which seem to have arisen during data input (transposition errors, omission of digits, etc). While a minority of PCTs appear to have allocated different proportions of costs to different cancer

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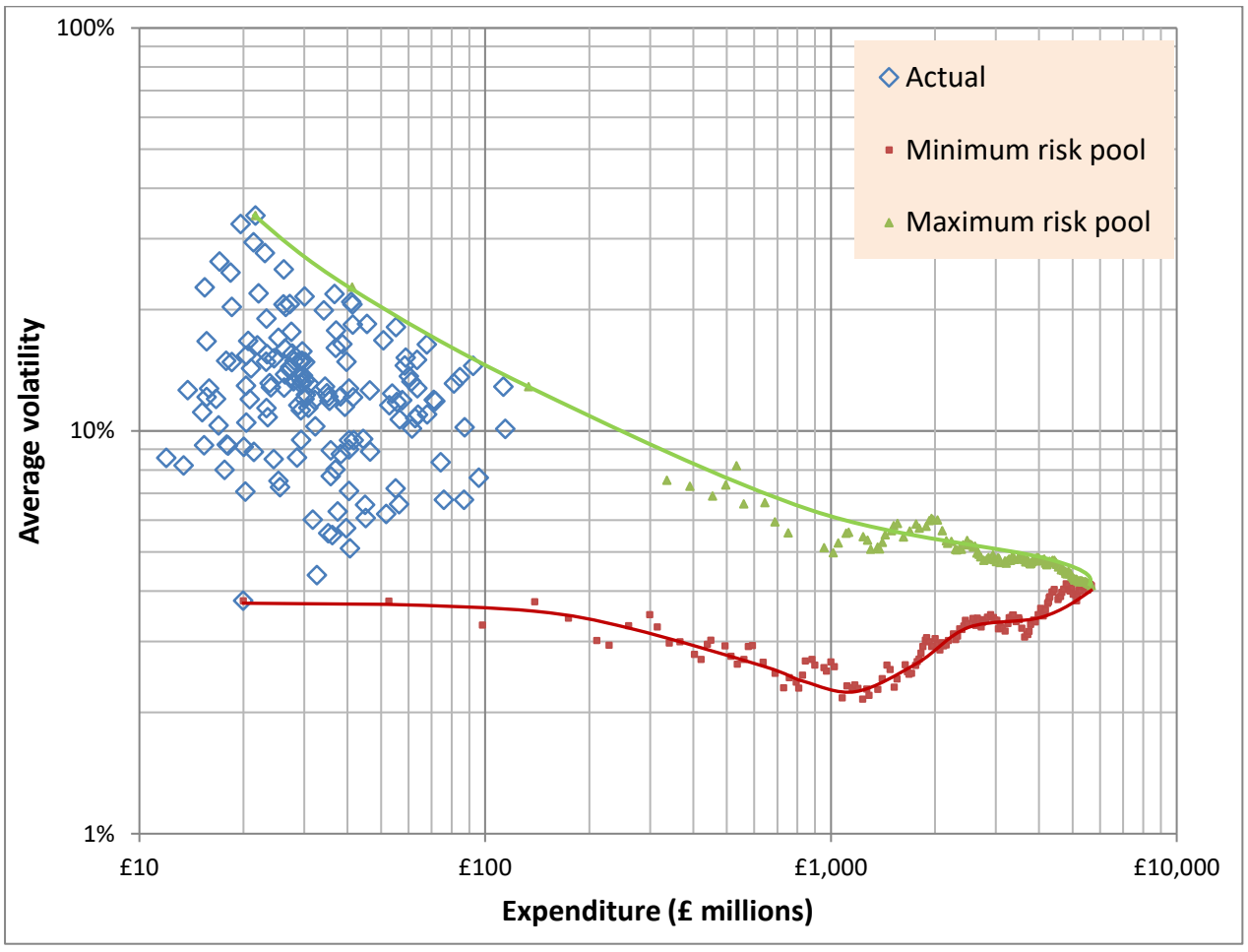
categories they appear to have done so in a consistent way and hence the analysis of year-to-year volatility has not been affected. New cancer registrations (all ages) in white Americans between 1999 and 2007 were extracted from http://www.cdc.gov/cancer/npcr/uscs/2007/download_data.htm and were analysed in the same manner. The 99.99% confidence interval for Poisson-based volatility in new cancer registrations was determined by Monte Carlo simulation (Oracle Crystal Ball) using the average of eight paired differences arising from nine data points and a minimum of 10,000 simulations.

Results

The volatility associated with total cancer expenditure for PCTs is given in Figure 1 where it can be seen that the range between maximum and minimum volatility is 10% to 50% at £10 million falling to 3.2% to 15.8% at £100 million. The volatility increases rapidly (the charts have a log-log scale) as size diminishes and this merely confirms the conclusion of a host of studies that small commissioning entities cannot be financially stable and explains why health insurance companies typically have more than one million members (Woolhandler et al 2003).

Figure 1: Volatility in total cancer expenditure



Footnote: Each data point represents a single PCT (location) over the period 2003/04 to 2010/11. National average volatility is 4.4% and the actual data falls between two parallel lines with a minimum calculated as 0.316 x √total expenditure/total expenditure and a maximum calculated as 1.58 x √total expenditure/total expenditure. The programme Budgeting data for total cancer expenditure appears to be consistent and less than 10 out of 1216 data values required adjustment to compensate for the consequences of data input errors (transposition and omission errors) at the level of the individual cancer groups.

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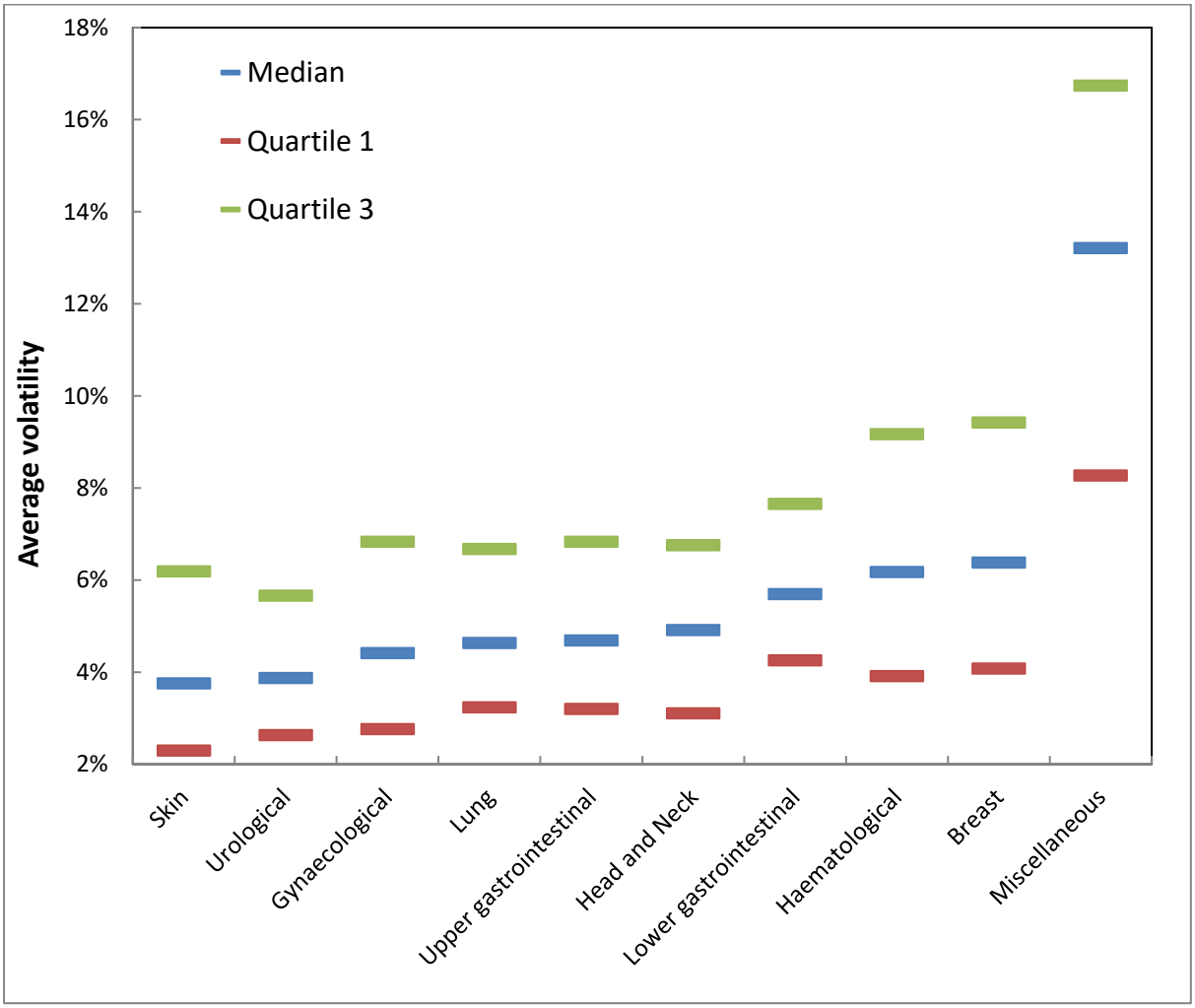
It would seem that CCGs had no prospect of ever remaining smaller entities than the PCTs which preceded them. At national level (£5.6 billion) the volatility is only reduced to 4.4% and the much higher volatility at individual PCT level confirms the fact that cancer expenditure is a source of considerable financial risk and knock-on pressure elsewhere in the total (fixed) budget. As has been reported for total expenditure and inpatient occupied bed-related expenditure (Jones 2012c,d) there is a considerable location specific element to the level of risk, i.e. we are dealing with expenditure which appears to be principally environment (location) sensitive.

Also shown in Figure 1 are the lines describing the maximum and minimum volatility experienced by larger risk pools comprising aggregates of PCTs. As can be seen, depending on which locations are in the larger risk pools there is still a considerable range in volatility and the absolute minimum possible volatility is around 2.3% for a particular mix of disparate PCTs with total expenditure around £1 billion although for another mix of PCTs with the same total expenditure the volatility is still around 5% to 6%. Expenditure of £1 billion implies six large regional risk pools which could experience volatility anywhere between these extremes. This suggests that equity can only be achieved by conducting the final risk equalization at national level otherwise the inherently high financial risk will still create the equivalent to a postcode lottery even in large regional risk pools.

Figure 2: Volatility associated with cancer groups



Footnote: Volatility for every PCT and cancer group has been adjusted to give the equivalent at £50 million annual cost, i.e. data points are moved parallel to the minimum and maximum lines shown in Figure 1. The median and quartiles are then calculated using this adjusted data.

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To investigate if this high volatility may be arising from particular cancers the volatility associated with the ten cancer groups used within the Programme Budgeting data is shown in Figure 2. Volatility in each group has been adjusted for size and the median and upper/lower quartiles calculated. On this occasion the median (sometimes called the robust mean) has been used because it avoids the undue influence that outlying values can have on the calculation of the average. As can be seen particular cancer types, notably, lower gastrointestinal, haematological, breast and miscellaneous show higher average volatility indicative of the action of particular environmental factors. Recall that the quartiles are not confidence intervals but merely delineate the points of 25% increments in the number of PCTs. This is a measure of the spread of the data and hence lower gastrointestinal and urological groups show the least spread, i.e. the smallest gap between the first and third quartiles. This could imply that there are fewer environmental factors affecting the expression of volatility for particular cancers within these groups. From a risk sharing perspective the costs associated with cancers in the 'Miscellaneous' group (and probably any low volume/very high cost cancers from the other groups) would be better placed into regional risk pools.

Table 1: Proportion of costs arising from different care settings

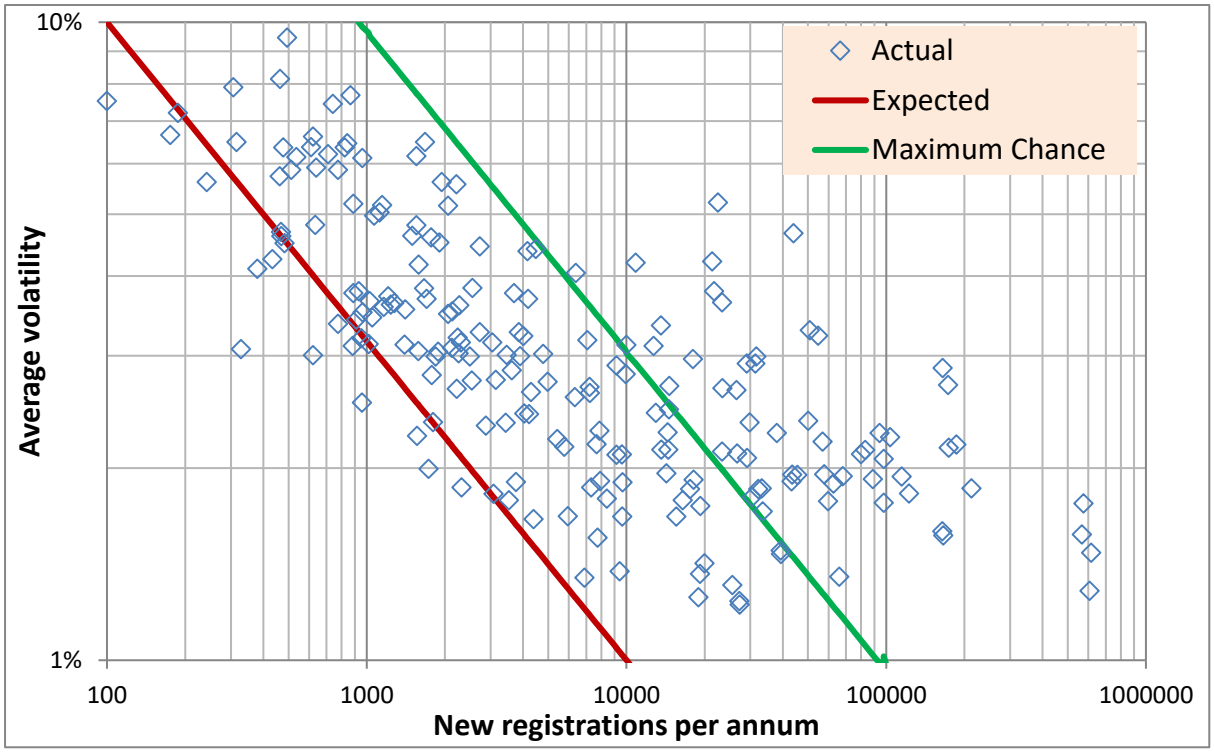
Cancer Category	Care Setting								
	Elective & Daycase	Other secondary care	Non elective	Outpatient	Primary prescribing	Community Care	Health & Social care: other setting	Non health/social care	Health Promotion
All Cancers	30%	21%	14%	9%	8%	6%	6%	4%	3%
Skin	79%	4%	7%	1%	0%	4%	1%	3%	0%
Urological	48%	4%	17%	1%	22%	2%	2%	3%	0%
Gynaecology	38%	8%	17%	14%	0%	5%	2%	4%	11%
Lung	36%	8%	39%	1%	0%	7%	4%	4%	1%
Upper GI	43%	7%	38%	1%	0%	4%	3%	4%	1%
Head & Neck	27%	45%	8%	2%	0%	7%	3%	8%	0%
Lower GI	52%	7%	25%	1%	0%	3%	2%	4%	6%
Haematological	46%	25%	19%	3%	0%	2%	2%	4%	0%
Breast	31%	9%	4%	18%	23%	2%	2%	4%	8%
Miscellaneous	20%	27%	11%	11%	7%	9%	9%	4%	2%
Weighting	0.023	0.004	0.000	0.188	0.012	0.000	1.183	0.000	0.000

Footnote: Costs are from 2010/11 when the care setting categories were first introduced. Other secondary care will include high cost drugs.

In an attempt to determine which care settings influenced the volatility for particular cancer groups the costs associated with different care settings are presented in Table 1 where it can be seen that for most cancers secondary care costs dominate the make-up of the total cost. Exceptions are breast and urological where primary care prescribing and pharmaceutical costs become important. The median volatility in Figure 2 was then predicted from a formula which applied weightings to each care setting which were then added across all care settings. As can be seen this simple model suggests that volatility is predominantly driven by costs in the other health & social care costs setting (a high proportion of the miscellaneous cancer costs) followed by outpatient, elective and primary

prescribing costs. This model is simply a start toward understanding how volatility cascades through the settings in which care are delivered and demonstrates that different components of total costs may be influenced in different ways.

Figure 3: Average volatility in cancer registrations in the USA



Footnote: Calculated average volatility has been adjusted for growth over time as was the data for Figure 1.

Having established that particular cancer types in England show higher volatility and implied environmental sensitivity than others this general principle can be explored in even greater detail using counts of newly diagnosed individual cancer types from the USA. This has been presented in Figure 3 where new registrations covering 68 cancer sites for male, female and both genders has been analysed for volatility over a nine year period between 1999 and 2007. As can be seen the majority of cancer sites are only moderately sensitive to the wider environment and lie between lines that could be described by simple chance variation. Moderate environmental sensitivity is implied by the fact that the points mainly lie above the average expected from chance. The upper line for chance is equivalent to the 99.99% confidence interval and hence any cancer-gender combination lying above this line can be considered to have at least one major environmental directly linked risk factor which has shown change(s) over time (Table 2). The key point is that the more extensive US data confirms the data from England (Figure 2) including previous studies regarding particular programme budgeting categories and sub-categories which go beyond just cancers (Jones 2010c). As can be seen many involve both genders but some are specific to just one gender even thought the cancer is possible in both genders, i.e. female breast but not male breast, etc.

The possibility of gender specificity in volatility, i.e. one gender is showing higher environmental sensitivity than the other is explored in Figure 4.

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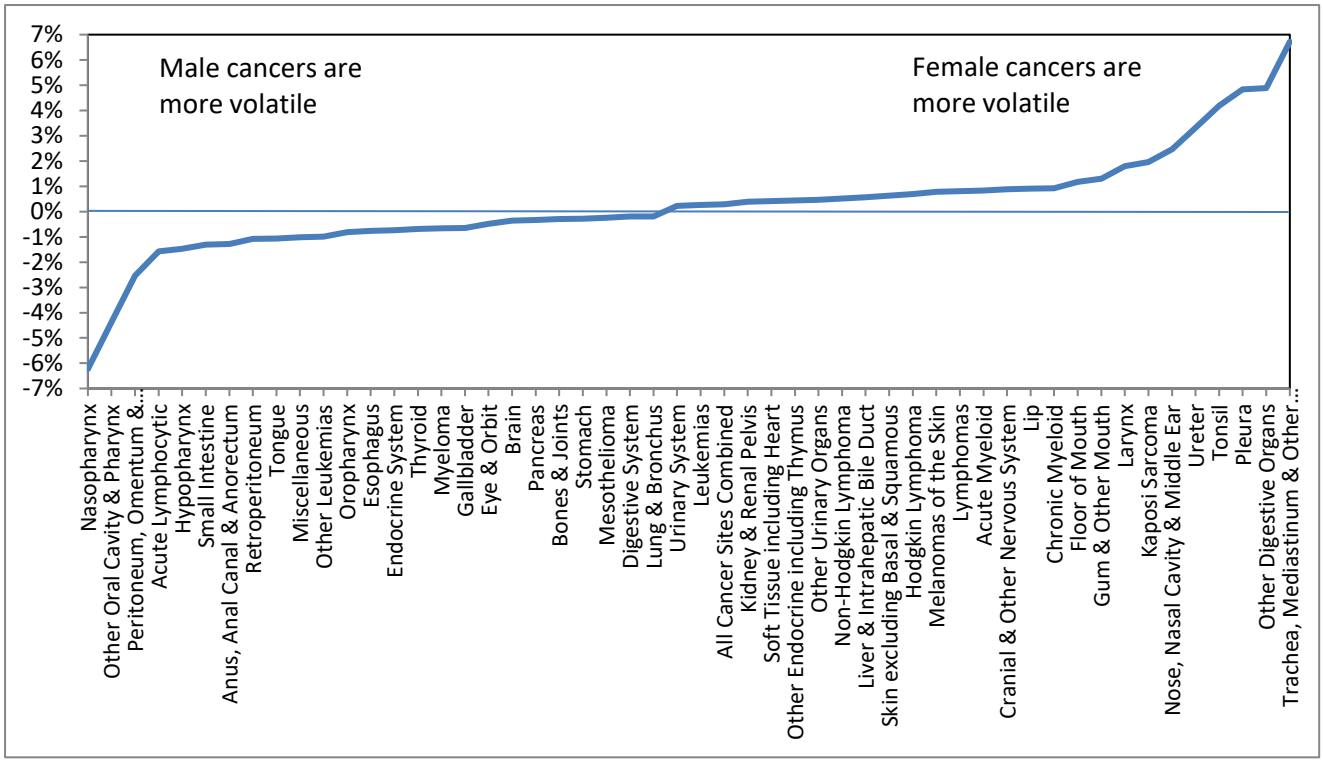
Table 2: Cancer sites with 100% certainty of environmental sensitivity

Gender	Site
Male	Chronic Lymphocytic
Both	Rectum
Both	Colon
Female	Corpus
Female	Uterus, NOS
Both	Digestive System
Male	Esophagus
Female	Breast
Both	Genital System
Both	Kidney and Renal Pelvis
Both	Leukemias
Both	Lung and Bronchus
Both	Lymphomas
Both	Melanomas of the Skin
Both	Miscellaneous
Both	Non-Hodgkin Lymphoma
Male	Prostate
Both	Rectum and Rectosigmoid Junction
Both	Respiratory System
Both	Skin excluding Basal and Squamous
Male	Urinary Bladder
Both	Urinary System

Figure 4: Gender specificity in cancer volatility



Footnote: Excludes cancers unique to the reproductive system. There is no significant gender difference in volatility for cancer of the breast.

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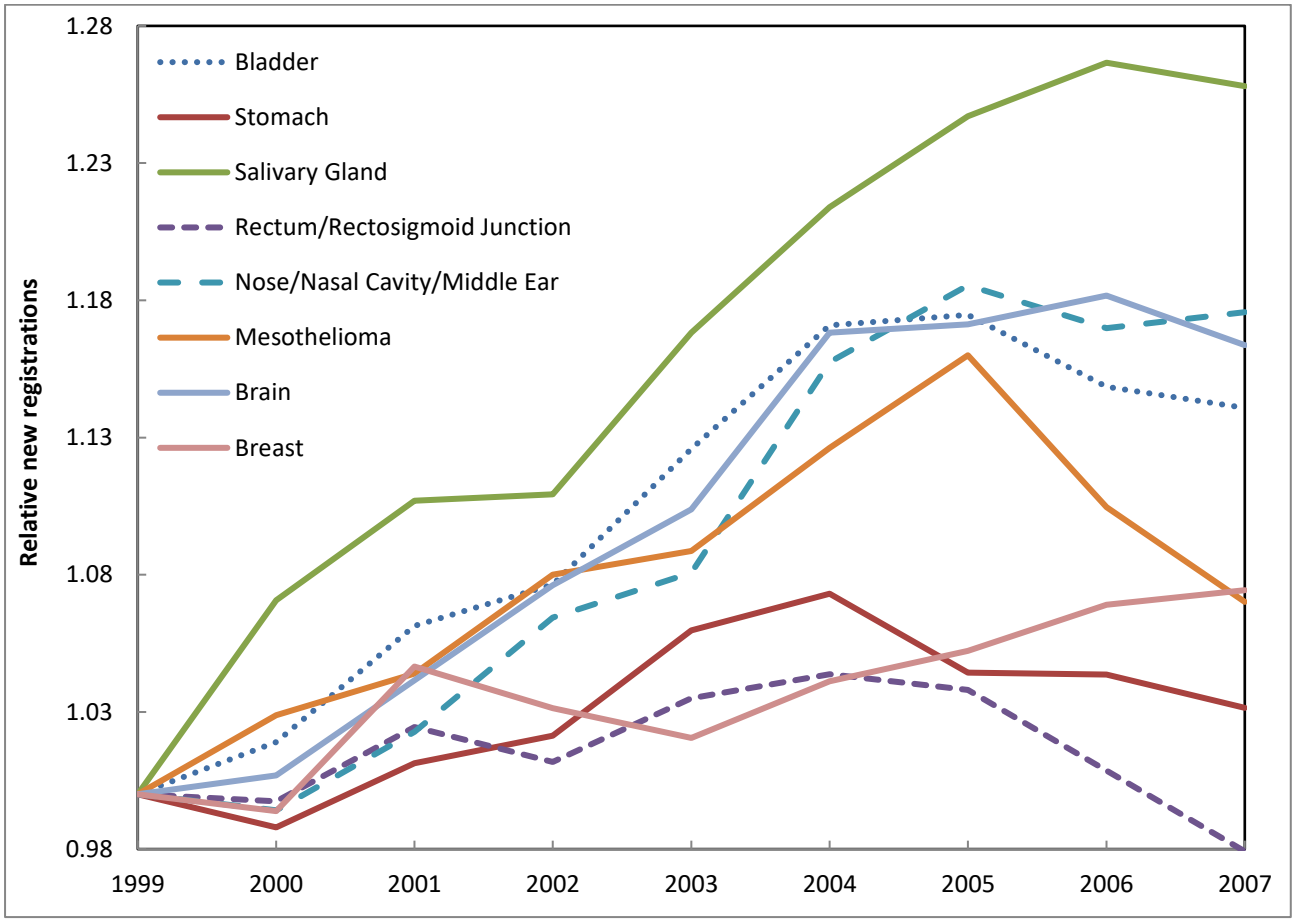
It would appear that gender differences in the volatility associated with many cancer sites is a fundamental feature of the financial risk implied in cancer commissioning. These results merely confirm earlier observations that the ratio of male to female cancer costs in the USA show long term cycles along with a number of other long-term conditions (Jones 2011b). The issue of gender specificity as a source of financial risk is discussed further in an accompanying article (Jones 2012f). Of particular relevance to the issue of financial risk is the fact that it is the cancers with the highest numbers (82% of all new registrations) where there appears to be the greatest degree of environmental sensitivity, i.e. the big number environment-sensitive cancers have greatest opportunity to create the overall high volatility observed for cancer costs.

Figure 5: Cyclic behaviour in cancer trends



Footnote: Data is raw count of new registrations which has not been adjusted for the underlying long term demographic trend.

The possibility of long term cyclic behaviour is explored in Figure 5 where it can be seen that certain cancers do indeed owe a significant portion of their apparent volatility to such behaviour and it is also possible that some cancers may show a time lag relative to others. For example, for salivary duct cancers the first cycle has commenced somewhere around 1999 while the second cycle commences around 2003 – whole year data prevents exact identification of the point of onset. There is opportunity for a third cycle to commence after 2007. These dates are very close to the onset of three events which are proposed to be due to outbreaks of a new type of infectious immune impairment in the UK and elsewhere (Jones 2012g).

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Discussion

Programme Budgeting costs are often criticised for being 'inaccurate' and such sweeping statements are not helpful. While certain PCTs may be allocating costs within certain groups in a (consistently) different way there is no evidence that costs at PCT level are a series of erroneous values. Such consistent bias will present problems within the context of attempting to benchmark the absolute value of costs but as long as any bias is consistent it does not affect the analysis of volatility. In this study gross errors could only be detected in around 0.5% of the values and these were adjusted to lie within the usual range in costs for that PCT. The next point for discussion is to explain why this and previous studies have all used direct counts of admission or cancer diagnosis/costs rather than the age standardised rates with which most researchers will be more familiar. The most obvious reason is that volatility is determined by changes in direct counts/costs rather than age standardised rates. Age related dysregulation of immune function appears to be associated with increasing incidence of cancer (Lustgarten 2009) and this relationship generates a good approximation to linear trends over time for many cancers. For particular cancers this linear relationship can then be modified by direct exposure to oncogenic or oncomodulatory infections (Oluwasola & Adeoye 2005, De Martel & Franceschi 2008). Hence growth- adjusted volatility, which assumes that the background growth is linear, is a very good approximation to reality, especially over the intermediate time frames, i.e. of up to ten years, in this study. This approach is confirmed by the fact that the majority of gender-cancer combinations in Figure 3 behave in a manner consistent with simple Poisson variation around a straight line trend.

The study of volatility is important because it reveals how sensitive a system is to changes in the multiple external environmental effectors. Hence while the proportion of people who smoke and/or the background levels of radon gas will increase the incidence of lung cancer they do not necessarily affect the year-to-year volatility which depends on *how rapidly and often* the other environmental effectors are changing.

The next issue is that the volatility associated with cancer costs arises from two sources. The first part is the volatility surrounding new diagnoses (as in Figure 3) while the second is the volatility arising from the fact that the cost per individual is subject to 'sampling error', in that each individual's costs are part of a wider cost distribution specific for each cancer type such that in the USA 16% of inpatient cancer costs are due to secondary malignancies, 12% for cancers of bronchus and lung, etc (Anhang Price et al 2102a). Costs for specific cancers also vary due to a number of factors. For example, breast cancer costs vary between the most affluent and most deprived groups due to the interplay between incidence, mix of invasive/non-invasive, age at diagnosis, proportion having reconstruction, etc (see http://www.ncin.org.uk/publications/data_briefings/breast_cancer_deprivation.aspx). As an overall generalisation among cancers there are higher rates in both incidence and mortality in the most deprived areas with the mortality ratio showing an almost linear increase with deprivation score (Donnelly & Gavin 2010).

It is highly likely that the shape of the cost distribution also shows environmental sensitivity (as was partly demonstrated in Table 1) given that all cancer patients are subject to a degree of immune impairment which can be exacerbated by the mode of action of particular cancer treatments, i.e. they are more susceptible to extremes of weather, air quality and local infectious outbreaks. Indeed patients with a secondary diagnosis of cancer are associated with a spectrum of admissions for: complications of surgical procedures or medical care 5.5%, pneumonia 5.2%, septicemia 4.4%, congestive heart failure 3.5%, chronic obstructive pulmonary disease and bronchiectasis 3.0%, cardiac dysrhythmias 3.0%, osteoarthritis 2.8% and fluid and electrolyte disorders 2.5% (Anhang Price et al 2012a). In terms of the role of the environment in new diagnoses there are a wide range of nutritional, lifestyle, occupational, environmental, gender, genetic and infectious factors are

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known to be involved in the development of particular types of cancer (see http://info.cancerresearchuk.org/cancerstats/?a=5441). Hence based on the exposure of individuals to these factors cancer cells will evade immune detection and commence a unique growth trajectory. Depending on the individual and any symptoms they will eventually seek medical advice and the cancer will be reported and counted at the point of diagnosis. The long-term trends in cancer incidence should therefore reflect the long-term changes in the risk factors. Adding these two sources of volatility together it is therefore not surprising that the volatility associated with total cancer costs in Figure 1 is both high and location specific.

The World Health Organisation (WHO) estimates that 40% of cancers are lifestyle and environment sensitive while 20% have an infectious origin (see http://www.euro.who.int/en/what-we-publish/information-for-the-media/sections/press-releases/2010/02/up-to-40-of-cancer-cases-could-be-prevented). Of relevance to the cycles in cancer incidence is the proposed existence of a new type of immune disease which appears to be international in scope and affects all dimensions of health care costs ranging from ambulance journeys, A&E attendance, GP referral and outpatient attendance, inpatient (mainly medical) admissions and bed occupancy (Jones 2010a-c, 2011a-c, 2012a-e) and perhaps also cancer incidence and costs. Specific patterns of incidence for particular types of cancer are a known by-product of HIV/AIDS or for transplant patients receiving immunosuppressive drugs. The exact range of cancers so affected is specific to the type of immune impairment exerted by HIV/AIDS or the immunosuppressive drugs with incidence of trachea, bronchus, lung higher in HIV/AIDS; colorectal, bladder, thyroid for immune suppressing drugs; and kidney, multiple myeloma, leukaemia and melanoma in both (Grulich et al 2008). Depression is also known to disrupt immune function and may lead to faster progression in some cancers (Spiegel & Giese-Davis 2003, Reiche et al 2004), and this is also reflected in a unique spectrum of cancers as the cause of death in those with depression (Onitilo et al 2006). Hence by extrapolation, the existence of a new immune-based impairment (were one to exist) should be accompanied by an increase in the incidence of a range of cancers specific to this particular kind of immune impairment. In this respect cytomegalovirus (CMV) is known to be oncogenic for salivary duct cancers, oncomodulatory for gliomas (a type of brain tumour) and is implicated in particular types of breast (Table 2 and Figure 5) and liver cancers (Barami 2010, Cox et al 2010, Harkins et al 2010, Lepiller et al 2011b, Melnick et al 2011, Tschische et al 2011, Soroceanu and Cobbs 2011), It would appear that the initial hypothesis is consistent with the patterns of at least some of the cancer types identified in this work. Additional cancer sites cannot be excluded since CMV is capable of infecting most tissue types and is known to prefer cancerous tissue (Lepiller et al 2011a, Jones 2012g) and for this reason further research is urgently required and is indeed ongoing in many institutes (see http://www.cmm.ki.se/en/Research/Cardiovascular-and-Metabolic-Diseases/Cell-and-Molecular-Immunology/Cia/Our-research/CMV-infection-in-cancer/).

With respect to the observed location-specific nature of volatility it should be noted that high spatio-temporal granularity is known to exist for infectious outbreaks such as pneumonia and influenza, West Nile Virus (WNV), severe acute respiratory syndrome (SARS) and cholera (Crighton et al 2007, 2008, Liu et al 2008, Ruiz-Moreno et al 2010, Cheng et al 2011). On this occasion we have the possibility of periodic outbreaks of an infectious agent which results in the segregation of the population in different locations into those who are infected and those who are not. Those who are not infected continue along the background trajectory for the development and subsequent diagnosis of cancers while those who are infected suffer the additional burden of an immune impairment which should speed the trajectory leading to diagnosis (Posnett & Yarilin 2005). The recent discovery that there are ten subtypes of breast cancer with unique patterns of gene expression (Curtis et al 2012) provides a potential basis for some of the observed environment sensitivity in other cancers and suggests a wider basis for the location specificity of the volatility in certain cancer costs observed in this study.

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Conclusions

The characteristic pattern of occupied beds and resulting volatility in costs seen in acute admissions, GP referrals, etc appears to also be reflected in cancer incidence and costs. Some have attempted to explain the changes in acute costs in terms of acute admission thresholds (Blunt et al 2010) although this is contradicted by other research (Sharma et al 2008) and by the fact that the effects are far wider than just acute costs and are international in scope. Cancer costs cannot be explained by acute thresholds since they are regulated by independent processes of cancer screening and diagnosis. Common cyclic patterns suggest common causes and infectious outbreaks would appear to be implicated. Whatever ultimate reason, the high overall volatility and wide range between locations suggests that there is no room for small players in this field and that equalisation or risk sharing is vitally important to avoid undue pressures in higher volatility locations – whether due to chance and/or environmental factors. Given the highly volatile costs associated with the 'Miscellaneous' group of cancers used within English Programme Budgeting they are best handled as part of a wider portfolio of other high risk (volatile) activities in larger regional risk pools which should share risk among themselves and over time rather than with their constituent CCGs. It would appear that the former PCTs were operated in an ideological vacuum where the discussion of risk was hindered by the assumption that financial variance arose from 'poor' management and that CCGs may have been promised modes of operation that are not supported by the reality of financial volatility.

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