Factors affecting the Demand for GMS Prescribing in Ireland: Derivation of a Weighted Capitation Formula

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Work in Progress

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ABSTRACT

The current indicative prescribing budgets for GPs on the GMS scheme in the Republic of Ireland are largely determined by the size of the GPs panel weighted for age. Using a sample of 140,000 individuals, annual prescribing costs for 1999/2000 are linked to data on individuals' socio-economic and demographic circumstances from an administrative database used to manage the population's eligibility for GMS services. Independent variables include age, sex, disability, lone parenthood, marital status, area of residence, access to GP services and chronic illness. Indicators of chronic illness are derived from the prescribing data based on the Chronic Disease Score methodology. We then construct indicative prescribing budgets based on these estimates. These are compared to the current prescribing budgets with respect to a number of policy-related characteristics, including morbidity and deprivation. The new formula is found to be more responsive to prescribing expenditure, while preliminary analysis suggests that it redistributes budgets towards practices with more morbidity and in deprived, urban areas.

1. Introduction:

The General Medical Services (GMS) scheme in the Republic of Ireland provides free primary care to about one third of the population. As part of the scheme, GPs are given indicative prescribing budgets. Prescribing budgets are determined largely on the basis of a GP's patient list weighted for age. Studies of prescribing demand, however, suggest that demographic, socio-economic and health status variables are important additional determinants[1,2]. This paper examines the factors affecting expenditure on prescription medicine in the Republic of Ireland by that section of the population in the GMS scheme, and constructs an alternative set of indicative prescribing budgets.

We create a dataset of 140,000 individuals that includes a number of predictors of prescribing expenditure such as demographic, socio-economic and health status variables. We then examine the distributive consequences of the resulting risk-adjustment formula in one health board area.

Section two describes the current GMS regime in Ireland and the budget setting mechanism in more detail, in order to place the current study in its policy context. Section three describes the dataset, provides descriptive statistics and outlines the methods used to estimate our expenditure function, drawing on previous risk-adjustment and weighted capitation literature.

Section five presents the results of the estimation of the expenditure function and describes its distributive consequences. Section six discusses these results and draws conclusions.

2. History of GMS Prescribing in Ireland

The General Medical Services (GMS) scheme, was set up under the Health Act 1970. GMS eligibility (also known as medical card entitlement) is granted to *'persons who are unable without undue hardship to arrange general practitioner services for themselves and their dependants'* (CSO, 1999, p. 100)[3]. The income thresholds for various groups are outlined in Table 1:

Table 1: Income Criteria for Eligibility for GMS for selected groups, March 2000

	Weekly Income Threshold (IR£)			
Group	**Age < 66**	**Age 66-69**	**Age 70-79**	**Age 80+**
Single person living alone	93.50	101.50	168.50	177.50
Single person living with family	83.00	88.00	146.00	152.00
Married Couple	135.00	151.00	252.50	265.00

Source: Southern Health Board, 2000

The majority of medical cards are granted on the basis of income, age and welfare entitlements. There are also medical cards granted to 'hardship' cases at the discretion of the Health Boards.

Until 1993 GMS prescribing was financed through retrospective reimbursement. In 1993 an Indicative Drug Target Savings Scheme was introduced. The scheme provided for *"the calculation of monetary prescribing targets for each General Practitioner taking into consideration the make-up of his/her patient panel"* (Dept of Health and Children, p. iii)[4], with a view to encouraging more rational and economic prescribing.

The objective of the Indicative Drug Target Savings Scheme is to give GPs an incentive to economise on their prescription of medicine. GPs who make savings on their drug budget are allowed to retain a certain percentage of the savings to spend on approved practice developments. Most recently, savings were split 50% to the GP and 50% to the Health Board, with additional grants also being paid to 'low spenders'.

Analysis of the Indicative Drug Target Savings Scheme has focused on the extent to which it has affected efficiency in the prescription of medicine or quality of prescribing practice[5]. The extent to which budget allocations accurately reflect the needs of patients, and therefore the extent to which it promotes equity in the distribution of prescribing resources has been underexamined. The basis for each GP practices drug budget is the number of persons on the practice's GMS list weighted by national average age-related prescription expenditure in each of seven age categories.

A certain percentage is also set aside to cover certain high cost drugs, known as 'budget-neutral' drugs. GPs also get a differential inflation uplift, depending on their previous year's expenditure. Therefore the criteria underpinning the budget setting process appear to be a combination of needs (list size, weighted for age), risk-sharing (prescribing bill for budget-neutral drugs is paid by the GMS (Payments) Board, who, because of its greater population, has a more predictable level of expenditure on these drugs than an individual general practice) and incentives (differential treatment of uplifts for inflation based on previous performance). This study focuses on the first consideration, that is, it examines whether additional variables should be incorporated into the budget setting methodology in order that it is more responsive to need.

3. Data

Data Description

The analysis is based on those people in four health boards areas – the Southern, Mid-Western, North Eastern and South Eastern – who were members of the GMS scheme for the entire cost year, a total of 415,271 individuals. Missing records – mostly relating to the disabled and lone parent variables, reduced the estimation population to 346,284. This is approximately 30% of the total GMS population nationally. We take a random sample of 140,000 observations with no missing records that is representative of the national population with respect to demographic variables. In order to prevent overfitting - reporting goodness of fit statistics that are misleadingly high - the sample is split into two halves, one for estimation and the other for validation.

GMS prescribing costs are analysed from September 1999 to August 2000 inclusive, except in the Mid-Western Health Board where the data are from October 1999 to September 2000 inclusive. Prescribing costs are exclusive of fees, VAT and 'budget neutral' drugs, while patients with prescribing costs of more than £2000 per year are also excluded, as per the calculation of Indicative Drug Targets.

Data on individuals' socio-economic and demographic circumstances are from the Medical Card Register. The Medical Card Register is a database held by each health board and used for the management of the population's eligibility for GMS services. Data were collected from the Medical Card Register from each of the four Boards at

slightly different times. Southern Health Board data are from April 2000; Midwestern Health Board data are from November 2000; North Eastern Health Board data are from October 2000 and South Eastern Health Board data are from October 2000.

The Medical Card Register contains a core set of data used for GP payment – age, gender, distance to GP's principal surgery and urban / rural area. We also use those non-core variables that are universally recorded, namely marital status of the head of the household; households in receipt of disability payments and households in receipt of one parent family allowance.

Prevalence estimates for a number of independent variables were compared to the 1996 Census of Population[6] at Health Board level and the 1995 Household Budget Survey[7] nationally. We found that estimates based on the Medical Card Register for disability, lone parenthood, marital status, residence in rural areas were not considerably different from estimates based on the publicly available data. The distance variable, however, may slightly overestimate the actual distance travelled by a patient for a consultation, since many GPs have branch surgeries while the distance variable measures distance to the principal surgery.

We carefully checked the data for any discrepancies which often arise in administrative databases. Only 170 anomalies, such as old age pensioners aged less than 65, were detected and removed, constituting 0.4% of the entire dataset.

The presence of chronic illness is measured using the prescribing data, based on the Chronic Disease Score methodology[8,9]. Any patient who has had four or more prescriptions of drugs identified as indicators of chronic disease over the 12 month period is assigned to the appropriate chronic disease dummy. For instance, those in receipt of four or more insulin prescriptions are assigned to the diabetes category. The original 28 chronic diseases are reduced to 10 either by combining categories or dropping them in order to provide a simpler model and because some of the diseases are uncommon in primary care. The manner in which the 28 were reduced to 10 is outlined in the Appendix.

Lamers[9] found that the prevalence estimates based on the Chronic Disease Scores were a little lower than those produced by a national health survey in the Netherlands. This could be because of underdiagnosis of certain illnesses, such as depression, and the use of alternatives to pharmacotherapy to treat certain conditions such as coronary heart disease and some mental illnesses. Despite this potential bias as a measure of need, the Chronic Disease Score is universally recorded for our study population, timely and provides a health status indicator validated by a doctor. It will be implemented as part of the revised risk-adjustment formula for sickness funds in the Netherlands[10] and is also used in risk-adjustment studies in the US[11].

Descriptive Statistics

Figure 1 illustrates the distribution of the annual prescribing costs for the estimation sample.

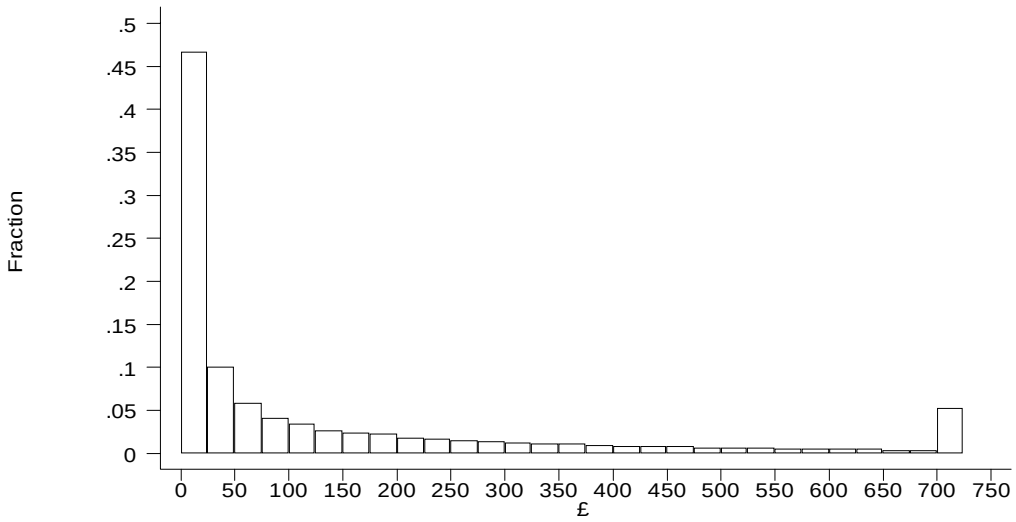

Figure 1. Frequency of Prescribing Cost

The distribution of prescribing cost is extremely skewed. Eighteen percent of the population had no prescribing costs, while 47% had less than £25. The mean cost is £151, but this is greatly affected by the 5% of the population who have costs in excess of £700.

Table 2 describes each of the variables in the study and shows their means, standard deviations and ranges for the estimation sample. Results were similar for the validation sample.

Table 2 Characteristics of GMS population

Variable	Description	Mean	Std. Dev.	Min	Max
Totcost	Annual prescribing expenditure (£)	151.25	269.60	0	1998.81
Age	Age	45	26.02	0	106.80
Gender	Female (= 1)	0.54	0.50	0	1
Disabil	Household in receipt of disability payments (=1)	0.12	0.32	0	1
Lonepare	Household in receipt of one parent family allowance (=1)	0.09	0.29	0	1
Marry	Marital status of head of household (married = 1)	0.41	0.49	0	1
Urbrur	Household in rural area (=1)	0.61	0.49	0	1
Dist1	Household less than 3 miles from GP's principal surgery (= 1)	0.61	0.49	0	1
Dist2	Household is 3-5 miles from GP's principal surgery (= 1)	0.14	0.35	0	1
Dist3	Household is 5-7 miles form GP's principal surgery (= 1)	0.20	0.51	0	1
Dist4	Household is 7-10 miles from GP's principal surgery (= 1)	0.03	0.18	0	1
Dist5	Household is 10+ miles from GP's principal surgery (= 1)	0.02	0.12	0	1
HB3	Mid-Western Health Board (= 1)	0.16	0.36	0	1
HB4	North Eastern Health Board (= 1)	0.26	0.44	0	1
HB6	South Eastern Health Board (= 1)	0.17	0.38	0	1
HB7	Southern Health Board (= 1)	0.41	0.49	0	1
CHD	Coronary Heart Disease	0.22	0.41	0	1
Epi	Epilepsy	0.02	0.13	0	1
Rheum	Rheumatological illness, pain and inflammation	0.10	0.30	0	1
Diabetes	Diabetes	0.02	0.16	0	1
Glau	Glaucoma	0.01	0.12	0	1
Peptic	Acid peptic disease	0.07	0.26	0	1
Respir	Respiratory illness, asthma	0.08	0.27	0	1
Thyroid	Thyroid disorders	0.02	0.15	0	1
Pain	Pain	0.04	0.20	0	1
Psych	Psychiatric illness	0.12	0.33	0	1

The mean prescribing expenditure was £151.25 (median = £31.38), with a maximum of £1,998.81. The average age of people on the GMS scheme is 45, while 54% of them are female. Twelve percent come from households in receipt of disability payments; 9% come from households in receipt of one parent family allowances and 41% come from households where the head is married. While 61% of households are in rural areas, 61% are less than three miles from their GP's principal surgery. The percentage drawn from each health board varies from 17% in the Mid-Western and South Eastern to 41% in the Southern.

Twenty two percent of the sample are indicated as having coronary heart disease. Although this is greater than most population-based epidemiological estimates, the

GMS scheme serves mostly low income and elderly people, who have higher than average medical need. Twelve percent are indicated as suffering from psychiatric illnesses, while eight percent have asthma or other respiratory illnesses. Two percent of the sample have epilepsy; and two percent have diabetes. Population-based epidemiological estimates of both these conditions have produced similar results. Four percent are prescribed opiods regularly, and are therefore indicated as suffering from pain. Seven percent have acid peptic disease.

Methods

As outlined above the capitation model currently used for GMS prescribing in Ireland is based on 7 age categories only. We apply a linear regression of annual prescribing cost on the series of independent variables outlined in Table 2. Splines of age are constructed based on visual inspection of the relationship between age and prescribing cost, with knots at ages 16, 45 and 75. Although the skewed distribution of prescribing cost as exhibited in Figure 1 suggests that we should consider transformations of the dependent variable, such as a logarithmic or gamma transformation, retransforming the results is problematic, especially in the case of a heteroscedastic error structure[12]. Almost all risk-adjustment models use an untransformed dependent variable as it is simpler for policy-makers to understand and is more stable than most alternatives[11,13]. However, given the non-normal error structure, confidence intervals are estimated by the percentile bootstrap, with 1000 replications.

The results are applied to one mixed urban/rural health board area with one medium-sized city. Budgets are constructed based on the new formula and compared with the old formula. Since we only with to compensate GPs for differences in health need, when we construct the prescribing budgets, we neutralise the effects of our supply-side variables, as well as those needs variables with counter-intuitive signs. This is in line with most risk-adjustment practices[13,14].

5. Results

Data are analysed using STATA 7.0[15]. The factors affecting prescribing expenditure are presented in Table 3.

Table 3 Determinants of Prescribing Expenditure

Variable	Coefficient	95% Confidence Interval	
Intercept	-6.21	-12.96	0.53
Age015	1.51**	1.23	1.79
Age1544	0.30**	0.13	0.46
Age4574	0.09**	0.11	0.30
Age75+	-1.36**	-1.96	-0.66
Gender	-1.48	-4.55	1.07
Disabil	25.87**	20.00	31.12
Lonepare	-3.77*	-6.88	-0.34
Urbrur	3.51*	0.23	6.78
Marry	-1.54*	-4.85	1.56
Dist2	-4.62*	-8.55	-0.63
Dist3	-0.23	-4.04	3.76
Dist4	-2.56	-10.34	6.04
Dist5	2.97	-8.48	14.68
HB3	7.85**	4.04	11.71
HB4	9.72**	6.46	12.85
HB6	5.41*	1.18	9.55
CHD	153.30**	147.98	158.31
Epi	174.41**	153.41	195.29
Rheum	122.80**	115.55	130.07
Diabetes	274.66**	256.47	292.27
Glau	172.13**	155.21	190.91
Peptic	295.84**	286.11	305.31
Respir	190.24**	181.58	198.47
Thyroid	23.90**	11.42	37.31
Pain	119.14**	106.15	131.25
Psych	195.96**	188.48	203.25
Adjusted R^2 (%)	53.54		
F statistic	3362.06		

*Significant at the 5% level

** Significant at the 1% level

The reference categories for the distance dummies and the Health Board dummies are Dist1 and HB7 respectively, as these best approximated the mean prescribing expenditure for the entire population.

The adjusted R^2 for the estimation model is 53.54%, which is high for most cross-sectional studies and especially studies of the demand for health care. It is 52.73% for the validation sample. As expected given the distribution of the dependent variable, the model's error structure was non-normal, requiring us to use non-parametric

techniques to estimate standard errors. We bootstrapped the model 1000 times which we expect to be adequate to produce robust standard errors.

All four age splines are significant. They indicate that prescribing expenditure increases by £1.51 for each additional year up to age 16. Thereafter it rises by £0.30 for each additional year from 16 to 45, as well as the £24.16 (£1.51*16) up to age 16; it rises by £0.09 for each year from 45 to 75, as well as the £32.86 up to age 45 (£1.51*16 + £0.30*29) and finally it falls by £1.35 for each year from 75, in addition to the £35.56 up to age 75.

Gender is unexpectedly insignificant. Disability has a strong positive relationship with prescribing, as expected, while living in a rural area is also positive. We expected, however, residence in a rural area to be negatively signed, as rural areas tend to have poorer public transport facilities than urban areas, upon which many GMS recipients would depend. As such we expected the access costs of attendance at the GP to be greater and prescribing expenditure less. We do find, nevertheless, that living 3-5 miles from the GP is negatively related to prescribing, compared with living less than 3 miles. The other three distance variables are insignificant.

Being married appears to have a slight protective effect on one's health, as expected, while lone parenthood is unexpectedly negatively signed. The Health Board dummies are all positive.

All chronic disease indicators are strongly positive, varying in effect from an increase of £23.90 in prescribing cost for patients with thyroid disorders, to £295.84 for patients with acid peptic disease. The coefficients on some chronic disease scores will be dampened by the prior removal of budget neutral drugs. For instance the removal of statins reduces the coefficient on the coronary heart disease indicator.

Preliminary Examination of Distributional Consequences

Table 4 shows the characteristics of GP practices for the third of practices that lose most from the change in formula and the third of practices that gain most - the losers and the winners.

Table 4 Comparison of Practices who are Losers and Winners from change in Formula in one Health Board

Indicator	Bottom Third	Top Third
% aged over 70	27	23
% Female	57	57
% Disabled	11	17
% Lone Parent	7	9
% Married	44	42
% Rural	75	47
% City	18	52
% CHD	22	26
% Epilepsy	2	2
% Rheumatology	9	13
% Diabetes	2	2
% Glaucoma	2	2
% Acid Peptic Disease	5	10
% Respiratory, Asthma	7	9
% Thyroid	3	2
% Pain	3	6
% Psychiatric	11	16

The current formula favours practices with a high percentage of elderly patients much more so than the new formula. As we can see the third of practices who would lose the most from a change in regime have a higher percentage of over 70s than the third of practices who would gain the most. Differences in gender and marital status are quite small between the two groups of practices, while the winning third have a much higher percentage of their patients who are from households in receipt of disability payments and a slightly higher percentage of patients from lone parent households. Probably the most striking result is the urban / rural divide between winners and losers. Losing practices have 75% of their patients living in rural areas as against only 47% of winning practices. Meanwhile, only 18% of losing practices come from the city, while 52% of winning practices come from the city.

With the exception of thyroid disorders, chronic illnesses are at least as prevalent in the winning practices as the losing practices. There is a higher prevalence of acid peptic disease, psychiatric illness, coronary heart disease, rheumatological disease, pain and respiratory disease including asthma in winning practices. Perhaps not surprisingly there is no difference in prevalence of diabetes, since diabetes is strongly

related to age and losing practices have a higher percentage of over 70s than winning practices.

6. Discussion and Conclusions:

A GP's GMS panel is currently adjusted for age only to determine their indicative prescribing budget. We developed an alternative weighted capitation formula based on the regression of demographic, socio-economic and health status indicators on prescribing expenditure.

The model we developed explained 53% of prescribing expenditure in the estimation sample and 52% in the validation sample. This compares with the current formula explaining 10% of variance. Explained variance is considerably higher in our model that in other weighted capitation models using individual level data. A basic age-sex model usually explains no more that 1-3% of health care expenditure, while a model with similar variables to ours which will be applied to the Dutch health care system in 2002 explains only 9% of variance. Meanwhile in studies of the demand for prescribing, Street et al[1] explained only between 8% and 13% of the variance in prescribing expenditure in three Russian regions, while Grootendorst[2] found R^2 values of between 22% and 27% for prescribing in Canada, using two-part count models.

There are a number of possible factors explaining our higher than expected R^2. First, since our data are truncated at £2,000, many high cost outliers that might reduce explained variance in other studies are absent here. Second is the use of chronic disease indicators as proxies for health status. These are all significant, signed with expectations and informative. They essentially produce an indicative amount that each GP should spend on such patients. For instance, if a GP has a diabetic on his panel, the indicator for diabetes provides information to the GP on how much his peers are spending on the medical management of diabetes, controlling for age, sex and other relevant variables. Unfortunately, chronic disease indicators are generated from the same dataset as the dependent variable, which probably partly explains their significance and the high explained variance of the models. A Hausman test of endogeneity found that epilepsy, peptic disease, glaucoma and psychiatric illness were endogenous. Future work should attempt to tackle this problem, perhaps by generating chronic disease indicators from past prescribing utilisation rather than

utilisation contemporaneous with the dependent variable, or by finding a suitable set of instruments.

The lone parent variable and the rural variable were both signed 'counter-intuitively'. Lone parenthood is a good indicator of poverty in Ireland, and childhood poverty in particular. The negative coefficient on the lone parent variable could be due to greater difficulty in accessing a GP, rather than lower need among households headed by a lone parent. As such it is important to suppress the coefficient when calculating budgets, since we have no wish to penalise GPs with a disproportionate number of lone parent families on their panels.

This model includes three supply-side indicators. First there is access to services, as measured by the series of distance dummies. Second there is health board policy to prescribing, as measured by the health board dummies and third there is additional access costs of rural-dwellers, as measured by the rural dummy. The positive sign on the rural variable is puzzling. The straightforward interpretation is that not only do people in rural areas overcome their additional access costs, but their higher prescribing need means that the overall effect of living in a rural area is to induce higher prescribing cost. In order to test this hypotheses, further work should assess what types of ill-health rural areas might induce and examine whether additional prescribing costs in rural areas are in response to these types of illness. For instance rural areas might be more associated with social isolation, leading to depression, which may induce greater prescribing of psychiatric medicine. An alternative explanation is that rural dwellers will be car owners and as such will have lower access costs than urban dwellers, having controlled for distance to the GP.

Owing to data constraints, we were not able to include indicators of GP prescribing behaviour. However, age and sex of GP were included for a small sample of GPs for which data were available and both were insignificant, providing us with (extremely limited) evidence that these effects are not considerable. More refined and comprehensive supply-side variables would undoubtedly enrich the analysis.

Weighted capitation formulae in the UK have focused to a greater extent on the potential endogeneity of supply in estimating needs based on utilisation. Spatial

differences in supply depend on spatial differences in historic need and therefore historic utilisation leading to simultaneity bias if supply is included as a set of independent variables explaining utilisation. The UK approach as been to apply two-stage least squares to control for the effect of supply in estimating the relationship between need and utilisation. However the UK models are based on small area data. The problem of endogeneity is considerably weakened when one uses individual level data, as in this study. A Hausman test did not indicate endogeneity of any supply-side variables.

In a preliminary analysis of the distributional consequences of a change in formula in one health board area, we found that the formula redirected prescribing budgets from rural to urban areas, and especially to the city. Forty three per cent of the city's district electoral divisions (DEDs) were in the most deprived quintile nationally, according to the SAHRU deprivation index based on the 1996 census of population, as against 1%-2% in the rest of the health board area[16]. This suggests that the new formula is redistributing resources to more deprived communities.

The analysis of the distributional consequences of the formula highlighted a second potential concern regarding the inclusion of chronic disease indicators, that is, that they are merely rewarding GPs who prefer to prescribe or alternatively GPs who are gaming the formula. In the first instance, if this preference for prescribing is reasonable then no particular bias arises. For instance, there are alternatives to pharmacotherapy in the cases of coronary heart disease and psychiatric illness. It is not necessarily perverse for our formula to provide a bigger prescribing budget for those GPs who treat these conditions using medicine compared with those GPs who treat them using alternatives such as behaviour modification programmes. However, given evidence of inappropriate prescribing of proton pump inhibitors in primary care(ref), if a preference for prescribing is inefficient then we do not wish our formula to reward it. In the second case, since the GP controls the number of items he prescribes for a particular chronic condition and he knows by how much his budget will increase the following year if his panel is indicated as having an additional person suffering one of the chronic diseases included in the formula, then he has an incentive to prescribe items that will indicate a chronic disease as long as the cost of such prescribing in the current year is less than the increase in his budget the following

year. For instance it is possible for a GP to write someone four antacid prescriptions and get the person indicated as suffering from chronic peptic disease generating an additional £295 onto the GPs budget the following year. However, these actions are conceptually similar to 'DRG-lift' and are not impossible to monitor. As mentioned above the Dutch health care system will apply the Chronic Disease Score methodology as part of its new risk-adjustment formula, despite its potential for gaming. Thus, we believe that the implementation of the new formula would require additional monitoring of GP prescribing behaviour and appropriate sanctions if GPs are found to be gaming the formula.

Weighted capitation models based on utilisation data will not produce an equitable distribution of resources in the presence of systematic unmet need. There is good evidence that the poor use health services less than the rich, having controlled for health status. For instance, in Scotland a positive relationship between deprivation and prescribing expenditure weakened considerably for high levels of deprivation[17]. Some risk-adjustment formulae have tried to incorporate unmet need in their model. For example, there is evidence that the Maori population in New Zealand under-utilise health care services. Therefore, resources are allocated on the basis of how much health care the Maori population would be expected to consume if it consumed at the same rate as the non-Maori New Zealand population for any given level of need, as measured by under-65 SMR[18] (REF Rice et al, 1999:62). In this instance the coefficient on psychiatric illness probably underestimates the true cost if treating all psychiatric illness in the community because underdiagnosis is common, relative to other illnesses. Moreover, if a poor person is less likely to be diagnosed as having a psychiatric illness than a rich person, when both have the same illness, then prescribing budgets will be redirected away from the poor and to the better off due to this formula. The problem of unmet need is mitigated somewhat in this study by examining only the GMS population, who are from broadly the same socio-economic group. Nevertheless, consideration should be given to the potential for unwanted distributional consequences of the formula due to unmet need. Some solutions are to apply counter-factual utilisation patterns based on ethnicity (as is the case of the Maori adjustment in New Zealand), region (applying the pattern of utilisation in the region where unmet need is smallest) or applying policy-determined coefficients to indicators of deprivation. For instance we restricted to lone parent coefficient to be

greater or equal to zero. In the event is was equal to zero, but we could restrict it to be greater or equal to some positive number, under the assumption that these households have unmet need.

In conclusion, we estimated an expenditure function for GMS prescribing in Ireland and derived a formula for indicative prescribing budgets based on our estimates. We found the model to be much more responsive to prescribing expenditure than the one upon which the current prescribing budgets are based. The model was stable and intuitive in most of its coefficients, while preliminary analysis suggests that it redistributes prescribing budgets in favour of practices with greater levels of morbidity and in deprived, urban areas. We noted a number of outstanding research issues, including endogeneity of some of the chronic disease indicators, and the incentives for gaming and inefficient prescribing that the chronic disease indicators may produce. A more sophisticated analysis of the distributional consequences of the formula including tackling unmet need are also required.

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Appendix

Table A1 outlines the relationship between the original Chronic Disease Score categories and those used in this study.

Table A1 Combination of Chronic Diseases Score Categories

Variable	Corresponding Chronic Disease Score (CDS)	
CHD	CDS1	Coronary and peripheral vascular disease
	CDS3	Hypertension
	CDS7	Hyperlipidemia
	CDS11	Cardiac disease; arteriosclerotic cardiovascular disease; coronary heart failure
Epi	CDS2	Epilepsy
Rheum	CDS6	Rheumatological conditions
	CDS19	Gout
	CDS21	Pain and inflammation
Diabetes	CDS12	Diabetes
Glau	CDS13	Glaucoma
Peptic	CDS14	Acid peptic disease
Respir	CDS17	Respiratory illness, asthma
Thyroid	CDS18	Thyroid disorders
Pain	CDS22	Pain
Psych	CDS23	Depression
	CDS24	Psychotic illness (incl. bipolar disorders)
	CDS25	Anxiety and tension
Dropped categories	CDS5	Tuberculosis
	CDS8	Malignancies
	CDS9	Parkinson's disease
	CDS10	Renal disease (incl. ESRD)
	CDS15	Cystic Fibrosis
	CDS16	Transplants
	CDS20	Crohn's and ulcerative colitis

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