CLINICAL SCIENCE

The effects of new topical treatments on management of glaucoma in Scotland: an examination of ophthalmological health care

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Background: The management of glaucoma has been changed in the past decade by the introduction of new drugs. The impact of these changes on clinical care of patients was examined by examining operation and prescribing rates for glaucoma in four geographical areas of Scotland for the years 1994 to 1999.

Methods: A retrospective analysis of national health statistics: primary care prescribing data, hospital derived operation rates, consultant numbers, optometrist numbers, and eye test data, expressed by estimated population at risk of glaucoma. The outcome measures were prescribing volume and cost for glaucoma medications, and operation rates, corrected for population estimated to be at risk of glaucoma (PEG), for trabeculectomy, for Scotland as a whole, and for four geographical "regions" (north east, south east, central, and south west Scotland).

Results: Prescribed items per 1000 population estimated to have glaucoma (PEG) increased by 24.9% between 1994 and 1999. This was above the general increase in prescribing in Scotland (17.8%). This increase varied in the four health regions evaluated (14.3% to 31.9%). Prescribing of topical β blockers increased little (6.4%), but there was a large increase in the use of new products (topical prostaglandins, carbonic anhydrase inhibitors, and α_2 agonists), at the expense of miotics (47.7% fall), and older sympathomimetics. This change in prescribing pattern was accompanied by a 61.5% increase in cost (range 42.2% to 73.4% in the four regions). New drugs accounted for more than half of total glaucoma expenditure in 1999. Operation rates (corrected for PEG) fell by 45.9% (range 43.1 to 58.6%) between 1994 and 1999. Other indicators suggested increased activity in ophthalmic areas (for example, cataract operations, eye tests, numbers of optometrists and ophthalmic surgeons all increased). Within north east Scotland operation rates decreased and prescribing increased less than in other regions, both from lowest regional baseline in 1994.

Conclusions: The introduction of new drug classes has had dramatic effects on the prescribing of glaucoma treatments. There has been a decline in older treatments and an increase in new agents, which has been associated with a large reduction in operation rates for glaucoma in Scotland over 6 years. Comparison of prescribing and operation data indicates regional differences in healthcare delivery for glaucoma.

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Glaucoma is one of the commonest causes of blindness,[1–3] and the second largest cause of bilateral blindness in the world.[4] It is estimated that 6.7 million people worldwide are currently blind from glaucoma and only cataract is a greater cause of severe visual loss. In the United Kingdom glaucoma accounts for 12% of all cases of blind registration.[1] The vast majority of people with glaucoma do not become functionally blind, but the significant visual loss they suffer, and its subsequent effect on functional status, are not addressed by current statistics on blindness.

The majority of cases of glaucoma are the result of primary open angle glaucoma and its prevalence is well established in developed countries. Studies conducted in several European countries, and white populations in the United States, have consistently obtained a prevalence of glaucoma between 1.1% and 2.1% of the adult population, with increasing prevalence in the elderly.[2–9]

There are two main approaches to glaucoma treatment—medical and surgical (trabeculectomy); surgery often following unsuccessful medical therapy. Development of topical β blockers more than 20 years ago revolutionised the medical management of glaucoma. Since 1995 three new classes of drugs have been introduced: prostaglandin analogues, topical carbonic anhydrase inhibitors (CAI), and α_2 agonists. These agents were introduced as adjunctive therapy and now have an important place in management.

Optometrists act as the major source of referral of glaucoma patients to the hospital eye service.[10 11] Since treatment options are limited the delivery of health care for glaucoma may be examined by ascertaining rates of prescribing topical ophthalmic treatments and operative intervention in defined populations. We have therefore examined the pattern and trend of the use of treatments for glaucoma in Scotland, a relatively stable population of approximately 5.1 million, from 1994–9, basing our analysis on the expected prevalence of glaucoma in the population. We have previously reported in outline that new drug prescribing has profoundly reduced operation rate for glaucoma in Scotland.[12] In this paper we expand on our previous findings and explore regional differences in care pattern for glaucoma.

METHODS

The population likely to have glaucoma was estimated from age related estimates of prevalence in individuals aged 40 year and older, which were based on published epidemiological studies.[4 5] Evaluating all available reports that gave age specific estimates for prevalence of open angle glaucoma, Quigley and Vitale proposed a model to estimate the prevalence of glaucoma for each age from 40 to 90 years in white people.[4]

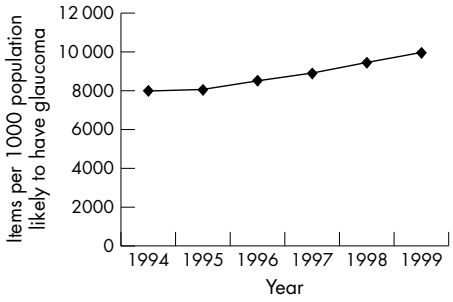

Figure 1 Items per 1000 population likely to have glaucoma, Scotland 1994–9.

Prevalence = $(1.59 \times 10^{-2}) - (1.14 \times 10^{-3}) \times (\text{age} - 30) + (3.39 \times 10^{-5}) \times (\text{age} - 30)^2$

For each year studied, in each health board, the estimated prevalence for each age band was applied to census projections of the population within that age band. These were totalled to give the likely number of patients with glaucoma in each health board and in Scotland as a whole.

To provide aggregated data at a level between health board and Scotland overall, four notional "regions" were defined around health boards with major population centres. These were: south west (Ayrshire and Arran, Argyll and Clyde, Greater Glasgow, Lanarkshire, Western Isles, and Dumfries and Galloway); south east (Borders, Lothian); central (Fife, Tayside, Forth Valley); and north east (Highland, Grampian, Orkney, Shetland). These regions have no formal status, and differ widely in area and character. Their populations aged 40 years and over in 1999 were (thousands): south west, 1132.2; south east, 404.5; central, 491.7; north east 371.6. It is anticipated that some cross boundary flow of patients would occur within these areas.

The Common Services Agency (CSA) of the NHS in Scotland collects data on all NHS prescriptions written by general practitioners in Scotland, dispensed by an NHS contractor (including dispensing doctors) and submitted for pricing to the practitioner services division of CSA. It does not gather hospital prescribing data, except for a very small number of prescriptions written in hospital and dispensed in the community. Information was available and extracted for all drugs in *British National Formulary* section 11.6: Glaucoma by active ingredient in five subsections: miotics, sympathomimetics, topical β blockers, carbonic anhydrase inhibitors, prostaglandin analogues,[13] for the years 1994 to 1999. Individual drugs were grouped according to their *BNF* subsection, and data also aggregated at this level. A number of drugs introduced during the period of the analysis were identified as "new drugs"—that is, new chemical entities (dorzolamide, latanoprost, brimonidine). These were included in the main analysis, but also analysed separately. The measure used for volume of prescribing was number of prescribed items per 1000 population estimated to have glaucoma (PEG). The measure used for cost of prescribing was gross ingredient cost per 1000 PEG.

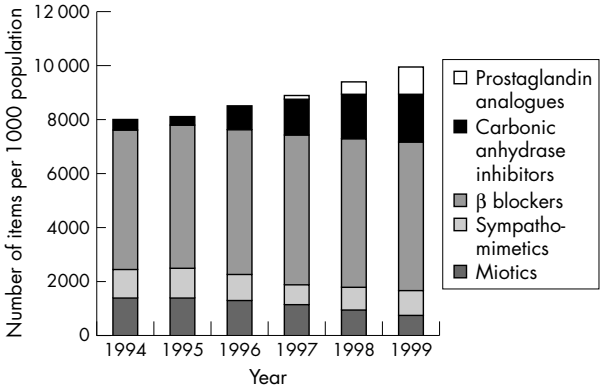

Figure 2 Number of items per 1000 population for Scotland in subsections of *BNF* Section 11.6.

The information and statistics division (ISD) of the NHS in Scotland collects information routinely on activity in Scottish hospitals using the Scottish morbidity record (SMR). Using the SMRs for acute hospital discharges (SMR01), all episodes were identified where a "trabeculectomy" (OPCS4 code C60.1, which includes phacotrabeculectomy and non-penetrating trabeculectomy) had been performed between 1989 and 1999.

Trabeculectomy, first described in 1968, is the standard surgical procedure to treat patients with glaucoma.[14] Rates of these operations per 1000 PEG were calculated for the period 1994 to 1999. Similarly, estimates were calculated for each region. Data of argon laser trabeculoplasty and laser cyclophotocoagulation procedures were also obtained. Waiting times (median wait in days) for admission to ophthalmology wards following placement on waiting lists and waiting times for outpatient appointments following a referral by a general medical practitioner were calculated from central data sets. In order to compare overall ophthalmic surgery activity, the numbers of SMR01 episodes where a cataract extraction had been recorded between 1989 and 1999 were also extracted.

Details of ophthalmology staff employed in the NHS in Scotland are collected by ISD via the Medical and Dental Census. This includes consultants and career grades including honorary appointments. Information relating to eye tests is gathered through an aggregated return (ISD(S)22) which is collected at 6 monthly intervals within each health board area. The Scottish Executive, directorate of primary care supplied the number of optometrists (ophthalmic opticians).

RESULTS

There was a 24.9% increase in items per 1000 PEG for Scotland, from 7950 in 1994 to 9930 in 1999 (Fig 1). Over this time there was a variation in prescribing increase in the regions studied, the range being 14.3 to 31.9%. In 1999 the total items per 1000 PEG varied from 8266 to 10,507 in the four regions (Table 1).

Table 1 Items (000s) and ingredient cost (£000s) for *BNF* Section 11.6 expressed per 1000 population likely to have glaucoma in Scotland

	1994		1995		1996		1997		1998		1999		% change, 1999 compared with 1994	
	Items	Cost	Items	Cost	Items	Cost	Items	Cost	Items	Cost	Items	Cost	Items	Cost
South west "region"	8.47	60.0	8.57	61.0	9.00	67.3	9.48	77.3	10.05	82.1	10.51	96.9	24.0%	61.3%
South east "region"	7.53	58.6	7.85	59.9	8.35	67.5	8.67	77.2	9.24	84.2	9.93	101.6	31.9%	73.4%
Central "region"	7.61	56.1	7.81	57.5	8.24	63.8	8.74	75.9	9.31	81.2	9.83	92.8	29.0%	65.5%
North east "region"	7.23	53.5	7.38	55.0	7.48	58.7	7.45	63.5	7.94	64.8	8.27	76.0	14.3%	42.2%
Scotland	7.95	58.01	8.11	59.22	8.50	65.31	8.89	74.94	9.44	79.67	9.93	93.70	24.9%	61.5%

Table 2 Percentage of items in subsections of *BNF* Section 11.6 per 1000 population likely to have glaucoma in 1999

	Scotland overall	South west	Central	South east	North east
Miotics	7.4%	6.9%	6.7%	10.3%	7.2%
Sympathomimetics	9.3%	11.2%	6.7%	8.5%	6.7%
β blockers	55.5%	54.4%	57.7%	54.6%	57.7%
Carbonic anhydrase inhibitors	17.1%	18.2%	14.1%	19.0%	15.1%
Prostaglandin analogues	10.7%	9.3%	14.9%	7.5%	13.4%

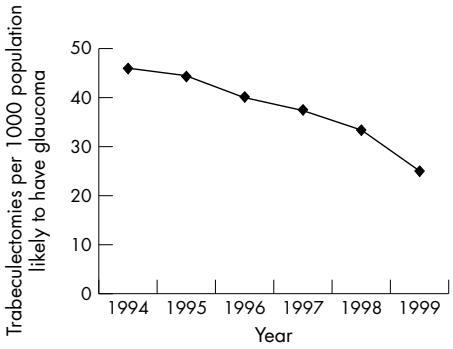

Figure 3 Trabeculectomies per 1000 population likely to have glaucoma, Scotland 1994–9.

Figure 2 shows the pattern of change for Scotland between 1994 and 1999 for glaucoma prescriptions. In 1999 there were 3109 prescription items for new drugs per 1000 PEG, of which 554 were for brimonidine. Thus new drug prescribing exceeded the overall increase of 1978 items per 1000 PEG between 1994 and 1999. Dorzolamide, a topical carbonic anhydrase inhibitor (CAI), was introduced in 1995 and by 1999 it accounted for 88.1% of CAI items. At the time of this study it was the only marketed topical CAI. The number of items per 1000 PEG for the oral CAI, acetazolamide, had fallen by 29.1% compared with 1994. Latanoprost (introduced in 1997) was the only prostaglandin analogue available and by 1999 accounted for 10.7% of all glaucoma prescribing. There was an overall decrease of 14.3% for sympathomimetics, but by 1999 the α_2 agonist brimonidine, introduced in 1997, accounted for 60.2% of sympathomimetic items.

Between 1994 and 1999, there was a 6.4% increase in topical β blockers but a 47.7% decrease in prescribing of miotics. In this analysis, the combination product dorzolamide and timolol was classified as a CAI. If classified as a β blocker, this would have reduced CAI items in 1999 by 11.2%, and increased β blocker items by 3.5%.

When regional prescribing was examined the β blockers were the most commonly prescribed and showed least regional variation in the proportion prescribed. There were differences in the rank order of prescribing for the other four groups of topical treatments (Table 2). In 1999, new drugs accounted for between 28.7% and 32.5% of items per 1000 PEG in the regions (compared with 31.3% for Scotland overall). This variation in the use of new drugs was much less when brimonidine was excluded (25.5–26.2%) although the profile of new drug use varied in the regions, as shown by their rank order.

Cost increased more rapidly than prescribing volume; the overall increase between 1994 and 1999 was 61.5% and by 1999 new drugs accounted for 54.5% of expenditure. This compares with a 28.1% increase in expenditure on all drugs in Scotland during this period. In the four regions the overall increase in cost per 1000 PEG between 1994 and 1999 varied between 42.2 and 73.4% (Table 1). In 1999 new drugs accounted for between 53.3% and 55.6% of costs.

Figure 3 shows the pattern of change for the annual number of trabeculectomies per 1000 PEG between 1994 and 1999. This fell by 45.9% for Scotland, and by between 39.8% and 58.6% in the four regions (Table 3). Over the same period, the number of operations for cataract (unadjusted for population) increased by 28.0%. The total annual number of operations for trabeculectomy in Scotland was 1202 in 1989, peaked at 1855 in 1993, and fell to 951 in 1999. Over the same 10 years, the annual rate of cataract operations increased by 98%, from 10 049 to 19 981.

A 1% sample of SMR01 records compared with case notes indicated accuracy for the main procedure recorded of 91%, with 81% for a secondary procedure in 1996.[15] Recent unpublished surveys suggest even better accuracy. We have excluded argon laser trabeculoplasty and laser cyclophotocoagulation operations (occasionally used to treat patients with glaucoma) from this analysis. In the period 1989–99 only 144 of the former (93 in one health board, Lothian) and 64 of the latter were done in Scotland, with considerable annual variation.

DISCUSSION

Prescribing for glaucoma increased above the average rate for prescribing generally in the period of this investigation. This increase in prescribing was unambiguously driven by the prescribing of new drugs. The number of prescriptions for the prostaglandin analogue latanoprost and the CAI dorzolamide were more than enough to account for all of the increased prescribing. Prescribing of brimonidine, an α_2 agonist, was also substantial, though this was at the expense of other sympathomimetics.

An increase in prescribing can be the result of more patients being treated, of existing patients being prescribed more items, or a combination of both. Since patient specific data are not available routinely we are not able to detect which of these possibilities apply to glaucoma prescribing. All three newer drugs are indicated for use when treatment with other agents for glaucoma have failed or are not appropriate. This suggests that a substantial proportion will be prescribed for patients already being treated, rather than just new patients. This view is supported by the relative stability in prescribing of topical β blockers, which remain the mainstay of prescribing for glaucoma. The population estimated to have glaucoma increased by only 2.8% during the period of the analysis.

Table 3 Trabeculectomies per 1000 population likely to have glaucoma

	1994	1995	1996	1997	1998	1999	% change, 1999 compared with 1994
South west "region"	45.8	39.2	36.1	38.0	34.0	26.0	–43.1%
South east "region"	52.3	41.0	44.2	34.6	25.8	24.5	–53.2%
Central "region"	46.6	48.4	35.2	30.2	23.0	19.3	–58.6%
North east "region"	43.9	46.4	41.9	40.6	38.9	26.4	–39.8%
Scotland	46.0	44.4	39.9	37.4	33.2	24.8	–45.9%

These prescribing changes have been accompanied by a large reduction in the number of operations for glaucoma. This is particularly surprising in view of published opinions of UK ophthalmologists advocating operative intervention as the treatment of choice.[16 17] Operative intervention is otherwise indicated following failed medical treatment. The number of trabeculectomies per 1000 PEG was 45.9% less in 1999 than 1994. The annual number of trabeculectomies in Scotland peaked in 1993, yet dorzolamide, the first of the new drugs, was not generally available until 1995. The rate of decline in operation rate fell by only 10.2% between 1993 and 1995, the rate of decline then accelerated, with a 25% year on year decline between 1998 and 1999. It is likely that supplies of newer drugs were available through clinical trials and/or compassionate use on a named patient basis before they were formally marketed and this may explain changes before 1995.

An association between changes in prescribing patterns and the fall in operation rates could be coincidental, or could be the result of confounding factors. However, a number of confounding factors were investigated and, where they have changed, it has been in a direction which would tend to favour more rather than less surgery. Thus numbers of optometrists (1995, 979; 1999, 1343), total eye tests (1995, 614 447; 1999, 657 213), eye tests for glaucoma sufferer or relative (1995, 46 845; 1999, 57 894), and ophthalmic surgeons (1995, 167; 1999, 182) increased, and outpatient and inpatient waiting times did not significantly lengthen. In contrast with glaucoma, the annual number of operations for cataract almost doubled over the 10 years between 1989 and 1999, with an increase of 28% between 1994 and 1999.

It will be important to monitor the future trend for operations. If glaucoma sufferers can be maintained on topical medical treatment for their remaining lifetime, with satisfactory control of glaucoma and no need for surgery, this would be beneficial. In this case the rate of surgery would be expected to stabilise at a lower level. Another possibility is that the need for surgery is being delayed rather than prevented, and that the new drugs merely delay surgery. This could be a less beneficial scenario if surgery is delayed to a point where visual function is being maintained less well than after surgery. This analysis cannot resolve these issues. It is also by no means clear that all new treatments are equally effective in preventing operation.

The prescribing of new drugs has increased expenditure. The cost to the NHS in Scotland for glaucoma drugs in primary care was £1.42m greater in 1999 than it was in 1994. This corresponds to about £37 per year for each person likely to have glaucoma. At the same time, the cost of surgical treatment of glaucoma will have fallen since 763 fewer trabeculectomies were undertaken in 1999 than 1994. Estimating the precise cost savings would require a more complex analysis; however, the average cost of an in-patient day in an ophthalmology ward in 1999/00 was estimated to be £605.[18]

This study also indicated considerable variability between health boards' operation rates, prescribing rates, and pattern of drug use. Combining the data into regions smoothed out some, but by no means all, of the variation. For example, in 1999 the north east "region" was well below the Scottish average for items per 1000 PEG (−16.8%) but above average for trabeculectomies (+6.2%). The equivalent comparisons were −1.1% and −22.3% for central; −0.04% and −1.4% for south east, and +5.8% and +4.8% for north east (Tables 1 and 3).

If one examines the change in behaviour since 1994 the lowest increase in prescribing (14.3%) and smallest reduction in operation rate (−31.8%) occurred in north east Scotland. This is a largely rural area which may make access to health care more difficult. It does, however, suggest a less progressive approach to glaucoma management. This assertion relies on there being no major change in the way in which drugs are supplied over the period of this study, in particular a shift to hospital dispensing. The relative stability of the topical β blocker prescribing leads us to believe such a change is unlikely.

In conclusion, we have shown changes in the management of glaucoma that indicate a major impact of new treatments on patient care. Differences in the pattern of prescribing and operation rates in different areas of the country raise concerns about the uniformity of healthcare delivery and patient management. Long term studies are required to ascertain the eventual impact of new therapies on patient prognosis in glaucoma.

CONTRIBUTORS

DNB had the original idea for the study. This was developed in discussion with MB, AA-B, and RC; analysis was planned by all the investigators and carried out by the authors within ISD. The manuscript was drafted by DNB with input from all authors.

Declaration of interests: RC, JF, and MB are employees of ISD. AA-B is a practising consultant ophthalmologist with a particular interest in glaucoma. No other interests declared.

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REFERENCES

1 **Evans J**, Rooney C, Ashwood F, *et al*. Blindness and partial sight in England and Wales:April 1990-March 1991. *Health Trends* 1996;**28**:5–12.
2 **Gibson JM**, Rosenthal AR, Lavery J. A study of the prevalence of eye disease in the elderly in an English community. *Trans Ophthalmol Soc UK* 1985;**104**:196–203.
3 **Martinez GS**, Campbell AJ, Reinken J, *et al*. Prevalence of ocular disease in a population study of subjects 65 years old and older. *Am J Ophthalmol* 1982;**94**:181–9.
4 **Quigley HA**, Vitale S. Models of open-angle glaucoma prevalence and incidence in the United States. *Invest Ophthalmol Vis Sci* 1997;**38**:83–91.
5 **Tuck MW**, Crick RP. The age distribution of primary open angle glaucoma. *Ophthalmic Epidemiol* 1998;**5**:173–83.
6 **Tielsch JM**, Sommer A, Katz J, *et al*. Racial variations in the prevalence of primary open angle glaucoma:The Baltimore Eye Survey. *JAMA* 1991;**226**:369–74
7 **Coffey M**, Reidy A, Wormald R, *et al*. Prevalence of glaucoma in the west of Ireland. *Br J Ophthalmol* 1993;**77**:17–21.
8 **Dielemans I**, Vingerling JR, Wolfs RCW, *et al*. The prevalence of primary open angle glaucoma in a population-based study in the Netherlands. *Ophthalmology* 1994;**101**:1851–5.
9 **Klein BEJ**, Klein E, Sponsel WE, *et al*.. Prevalence of glaucoma: the Beaver Dam Eye Study. *Ophthalmology* 1992;**99**:1499–504.
10 **Harrison RJ**, Wild JM, Hobley AJ. Referral patterns to an ophthalmic outpatient clinic by general practitioners and ophthalmic opticians and the role of these professionals in screening for ocular disease. *BMJ* 1988;**297**:1162–7.
11 **MacKean JM**, Elkington AR. Referral routes to hospital patients with chronic open angle glaucoma. *BMJ* 1982;**285**:1093–5.
12 **Bateman DN**, Clark R, Azuara-Blanco A, *et al*. The impact of new drugs on glaucoma management in Scotland- an observational study. *BMJ* 2002;**323**:1401-2.
13 *British National Formulary*, 40. London: British Medical Association and the Royal Pharmaceutical Society of Great Britain, September 2000.
14 **Cairns JE**. Trabeculectomy. Preliminary report of a new method. *Am J Ophthalmol* 1968;**66**:673–9.
15 **Harley K**, Jones C. Quality of Scottish Morbidity Record (SMR) data. *Health Bull* 1996;**54**:410–17
16 **Jay JL**, Murray SB. Early trabeculectomy versus conventional management in primary open-angle glaucoma. *Br J Ophthalmol* 1988;**72**:881–9.
17 **Migdal C**, Gregory W, Hitchings R. Long-term functional outcome after early surgery compared with laser and medicine in open-angle glaucoma. *Ophthalmology* 1994;**101**:1651–6.
18 *Scottish health service costs*. Edinburgh: ISD Scotland Publications, 2000.