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COSTS OF FLEXIBLE SIGMOIDOSCOPY SCREENING FOR COLORECTAL CANCER IN THE UNITED KINGDOM

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Abstract

Objectives: Colorectal cancer is one of the most commonly occurring cancers in industrialized countries, yet appears to be amenable to screening. Amongst the many possible protocols is once-only screening by means of flexible sigmoidoscopy. This protocol is currently being investigated in a UK multicenter trial and the study provides estimates of the expected resource costs.
Methods: The direct health care costs of sigmoidoscopy and of all subsequent procedures were estimated from an audit of resource use of approximately 40,000 patients at thirteen centers. Patient-borne costs were estimated from the results of surveys conducted at twelve of these centers.
Results: The health service costs of a flexible sigmoidoscopy was estimated at £56. The total costs of screening (including private costs) averaged £82 per person screened, although costs varied by center. The total health service costs of screening and subsequent management averaged approximately £91 per person screened, again with variations between centers.
Conclusions: Even within a strict trial protocol, intercenter variation in costs can be detected, ascribable to variability in local management practices, local yield, and local patient-borne costs. Other recent estimates of flexible sigmoidoscopy costs vary widely. As these costs form the basis of technology assessment simulation models which, in turn, inform policy, obtaining realistic cost estimates within the appropriate health care setting is of paramount importance.

Keywords: Colorectal cancer, Cost, Flexible sigmoidoscopy, Screening

With over 220,000 incident cases being recorded annually, colorectal cancer has become the most common cancer in the European Union (20). Over the past few decades, an improved

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understanding of the disease process, coupled with developments in diagnostic technology, has led to the realization that many cases of colorectal cancer could be prevented as a result of mass population screening (11;16;31). However, in publicly funded health care systems at least, the initiation of a national screening program is unlikely to be contemplated without evidence of cost-effectiveness.

Many alternative colorectal cancer screening methods appear feasible (55). The range of options includes fecal occult blood testing, radiology, and endoscopy, with various screening intervals and subject age ranges. Each method has its own particular strengths and weakness. Regular surveillance using the highly sensitive colonoscope, for example, would probably maximize the detection of neoplasia, yet the procedure is expensive, risks complications, and, being invasive, is unlikely to secure long-term compliance amongst the general population (32). Although low in cost, fecal occult blood tests have poorer sensitivity, and thus lower yield, in comparison with endoscopic investigations. The flexible sigmoidoscope is less expensive and safer than the colonoscope, although, given its restricted length, is likely to miss disease in the proximal colon (19;23;27). Accordingly, the search for the most cost-effective screening method involves balancing detection rate and disease prevention with program costs, safety, and long-term subject compliance.

By the early 1990s, flexible sigmoidoscopy screening had been demonstrated to be effective in preventing colorectal cancer, by means of detecting and excising premalignant lesions (33;40). The American Cancer Society began recommending regular screening using this method, although the appropriate screening interval remained indeterminate (22;26). As it had been shown that the probability of new lesions arising after negative sigmoidoscopy was low (37) and that, once excised, rectosigmoid lesions exhibited a low risk of subsequent "serious pathology" (6;54), a randomized controlled trial was proposed, in which each subject would be offered a single sigmoidoscopy (2). During this sigmoidoscopy, small polyps would be excised, whereas those subjects with high-risk adenomas (defined in terms of size, severity of dysplasia, villousness, and multiple presence) would be referred on to colonoscopy. The expectation was, therefore, that, as a result of such screening, each subject would be ensured of a clean distal colon, and a proportion would be ensured of a clean proximal colon also. The protocol accepted implicitly that a proportion of lesions—those in the proximal colon without distal markers—would inevitably be missed.

The UK flexible sigmoidoscopy (Flexi-Scope-FS) trial has offered its subjects a once-only screening sigmoidoscopy at age 60 years or thereabouts (46). The trial commenced in 1995 at a pilot site (5) and thereafter recruited subjects at thirteen hospital-based centers throughout Great Britain. Two centers were in Wales (Newport and Swansea) and one was in Scotland (Glasgow). The English centers were, to the north, Leeds, Liverpool, Manchester, and Newcastle; in the Midlands, Birmingham and Leicester; and, to the south and east, Harrow, Norwich, Oxford, and Portsmouth. This study presents estimates of the resource costs of flexible sigmoidoscopy screening according to the trial protocol and compares these findings with other sigmoidoscopy costing results.

METHODS

A total of 170,000 individuals were entered into the main trial, allocated approximately equally between the thirteen centers. A minimum 2:1 randomization between control and test groups was undertaken for each center and a common protocol for the initial screening of the test group was followed. The organization of each local program was the responsibility of a full-time administrator, who managed appointments, transmitted results, and maintained records. Each center was required to screen approximately 3,000 subjects over an eighteen-month period. The screening sigmoidoscopy was carried out by a registrar-level clinician using the Olympus sigmoidovideoscope system, and all excisable lesions smaller than 1 cm

in diameter were removed during the procedure. Additional clinical support was available, in the form of a consultant on call. Each center employed three nurses, one assisting the endoscopist, one sterilizing the equipment, and one familiarizing subjects with the procedure before examination.

The basic trial protocol envisaged a single sigmoidoscopy for each subject, followed by colonoscopic investigation of those for whom high-risk abnormalities had been detected (3). These latter subjects would then be treated (including colonoscopic excision where appropriate) and kept under surveillance. On the basis of current epidemiological knowledge, it was anticipated that most subjects at each center would either yield negative results or present with low-risk polyps excisable during the sigmoidoscopy examination. They would thereafter exit the trial and give rise to no further procedures or costs. It was foreseen, however, that, on occasions, the screening sigmoidoscopy might have to be repeated on particular subjects, owing to incomplete initial examination resulting from inadequate bowel preparation (43). The same point can be made for the subsequent colonoscopies. Furthermore, it was recognized that several cancers would inevitably be found, and those identified would require immediate treatment according to local surgical practice. Naturally, center-specific yield of adenomas and cancers could not be anticipated in advance.

The resource costs entailed by FS screening and postsigmoidoscopy management were estimated from the individual records of management for each subject, combined with the unit costs of those procedures which each subject experienced. Because postcolonoscopy surveillance occurs some years' after the initial screening/treatment episode, its costs have not been included in the present estimates. Irrespective of source and method of calculation, all costs reported have been converted to UK sterling at 2000 prices, using the GDP deflator when appropriate (£1 = $1.55 = €1.75, approximately).

Cost of Flexible Sigmoidoscopy

The cost of a single screening flexible sigmoidoscopy was estimated from an audit of resource use. These resources comprised labor, as described above, consumables, capital, and overheads. The clinicians in the trial were appointed on a joint service/research contract, and only the service element of their time was attributed to procedure costs. Consumables included, for example, bowel preparation (4), gloves, paper mats, polypectomy snares, biopsies (required for around 27% of examinations) and administrative requisites, such as stationery, postage, and telephone charges. Labor costs were estimated from average observed time required for the procedure and National Health Service (NHS) wage rates, whereas consumables were costed on the basis of NHS supply prices.

Capital was represented by the endoscopes and associated electronics, cleaning equipment, and carbon dioxide delivery systems, although administrative necessities, such as office furniture, computer equipment, and physical storage capacity were also included in the audit. As the endoscopy equipment used in the trial had been supplied at subsidized rates, we used market prices, obtained from the equipment suppliers (Keymed), in our capital cost estimate. Capital consumption included the cost of service agreements and overhaul/re-build, where appropriate. All centers were provided with a fixed management allowance to cover general overheads (use of hospital facilities). All capital equipment was depreciated over six years.

Private Costs

FS screening was provided to the subjects at zero price and financed both from the trial (Medical Research Council) and the National Health Service (NHS) Research and Development budgets. Were mass population screening to be implemented in the UK, it is probable that the direct clinic costs of sigmoidoscopy would be borne by the NHS. However,

clinic-based screening requires that subjects incur private costs, represented by the time expended in attending the clinics, plus the costs of travel. Private costs must be considered alongside direct NHS costs to encapsulate a true social cost estimate. In an earlier study (15), we estimated these private costs and presented average results for the trial as a whole. In the present study, however, the results from this earlier study are presented by center.

Full details of the private cost estimation method were provided in the earlier study. Briefly, our data were obtained from a large questionnaire survey (n = 3,525), in which subjects attending for screening reported their travel and appointment times, travel distance, mode of transport, travel expenses, and sociodemographic details. Travel costs were estimated using these data, combined with standard accounting costs, as determined by mode of transport. For employed subjects, time costs were estimated on the basis of occupation-specific wage rates in the region of the center, although standard accounting conventions were used for those not in employment. Many of the screening subjects were accompanied, entailing additional time and travel costs being incurred, and equivalent questionnaire data for the accompanying person were obtained to estimate these additional costs. Note that private costs were not collected for one center whose screening program had been completed before the private cost assessment was undertaken.

Costs Entailed by Screening

A review of subjects' management paths revealed that, as expected, the preponderance of subjects had exited the program immediately after a single sigmoidoscopy screen. A proportion required repeat sigmoidoscopies, either on the same day or on a subsequent occasion. In the former case, it was assumed that no additional administrative or private costs would be incurred whereas, in the latter, it was assumed that the procedure would both require readministering and entail further private costs.

For a minority, especially those requiring treatments for cancers, the management paths after sigmoidoscopy were complex. It was discovered that all such paths were describable as particular permutations of five elements. These elements were sigmoidoscopy, colonoscopy, radiological investigation, surgical intervention, and outpatient attendance. It was accordingly necessary to ascribe a unit cost to each of the last four. Although center-specific data were not readily available, the NHS does publish reference costs, i.e., national average cost estimates for certain types of management, derived from data provided by a large number of individual hospitals (10). The costs of a major surgical intervention and of an outpatient attendance were derived from this source. The former cost was £3,417, representing an average of costs for all surgical colorectal interventions, weighted by severity. The latter was £74, again a weighted average for general surgery cases. Reference costing, however, does not extend to the level of the individual procedure. The cost of colonoscopy (£187) was based on one quoted by the NHS at the time of the trial's commencement, whilst the cost of a radiological investigation (£72) was derived from an earlier audit study (50).

RESULTS

The health service cost of a flexible sigmoidoscopy conducted within the trial, based on an annual throughput of 2,000 procedures per center, was estimated at £56.1. Table 1 indicates the composition of costs. As may be inferred, 27.3% of costs were attributable to capital depreciation and 17.2% to screening administration.

Table 2 categorizes the procedures experienced by subjects during the trial by (anonymized) center. As is evident, the expected protocol—initial sigmoidoscopy, repeated if necessary, followed by colonoscopy, repeated if necessary—was adhered to for the vast majority of subjects. For the trial as a whole, 94.8% of subjects exited immediately after one or more sigmoidoscopies, the range across the thirteen centers being 91.2 to 96.5%.

Table 1. Cost of a Flexible Sigmoidoscopy

Resource	£, 2000	% of total
Endoscopist	8.2	14.6
Administrator	7.2	12.9
Consultant on call	2.4	4.3
Nurses	12.0	21.4
Histopathology	5.5	9.8
Drugs/consumables	1.3	2.3
Administrative expenses, including set-up costs	2.4	4.2
Management overheads	2.0	3.6
Sigmoidoscopes	10.0	17.8
Cleaning equipment & delivery system	2.5	4.5
Maintenance contract and servicing	2.6	4.7
Total	56.1	100.0

Table 2. Management Paths of Screening Subjects (%)

Center	Number screened	Exit	Same-day repeat & exit	Different-day repeat & exit	Colonoscopy & exit	Colonscopy & surveillance	Colonoscopy & surgery	Surgery alone	Other[a]
1	3,906	92.7	2.3	0.8	0.5	3.1	0.6	0.0	0.1
2	2,866	86.2	5.1	3.9	0.5	2.8	0.5	0.0	1.0
3	3,022	85.7	1.5	4.0	0.4	7.4	0.9	0.0	0.1
4	3,164	94.6	1.7	0.2	0.2	3.2	0.2	0.0	0.0
5	2,956	85.8	1.3	7.1	0.6	4.7	0.5	0.0	0.0
6	2,987	92.4	1.9	1.6	0.3	3.4	0.3	0.0	0.0
7	2,955	92.8	0.3	0.8	0.5	5.1	0.4	0.1	0.1
8	3,013	86.3	6.3	0.6	0.5	5.9	0.3	0.1	0.0
9	2,906	90.8	3.1	1.1	0.8	3.8	0.6	0.0	0.0
10	2,898	92.6	1.1	2.4	0.0	3.6	0.1	0.3	0.0
11	2,912	95.6	0.3	0.0	0.2	3.3	0.4	0.1	0.0
12	3,178	83.5	11.8	0.2	0.3	3.7	0.5	0.0	0.0
13	3,033	89.4	2.6	2.0	0.3	5.3	0.3	0.0	0.0
Total	39,796	89.9	3.1	1.9	0.4	4.2	0.4	0.0	0.1

[a] Comprises barium enema investigation and/or outpatient attendances.

Thereafter, colonoscopy and exit or surveillance followed in 4.6% of cases (range, 3.3 to 7.8%). As is evident from Table 2, management paths more complex than these were restricted to only small numbers of individuals at any one center. In some cases, these departures from protocol were minor. In center 2, for example, around 1% of subjects received a radiological examination after sigmoidoscopy, rather than colonoscopy, and the majority exited immediately thereafter. Management paths became particularly involved where a cancer had been detected. For one individual in center 7, for example, sigmoidoscopy led directly to surgery, followed by three outpatient attendances, and a follow-up colonoscopy. For a subject in center 9, the initial screen led to a radiological examination, colonoscopy, three episodes of surgery, and five outpatient attendances. For the trial as a whole, 163 subjects experienced outpatient attendances, typically in relation to cancer detection. The mean number of attendances in this group was 2.9, with 37% experiencing only one.

Table 3 presents cost estimates for the FS screening trial, by center. The first column lists private costs incurred per subject visit. The difference between highest and lowest cost is £12.5 and the standard deviation of the values is 4.3. The unit costs for the lowest five centers are significantly lower than those for the highest three (one-way analysis of variance at 5%, with Bonferroni correction). The variations are easily explained with reference to the differing characteristics of subjects attending each center. First, the proportion of employed

Table 3. Cost by Center (£, 2000)

Center	Private costs, per visit	Direct NHS costs of FS screening, per person screened (A)	Total direct costs of FS, screening, per person screened	NHS costs of all postscreening management, per person (B)	Total NHS program costs (screening plus management), per person (A + B)
1	—	57.5	—	35.5	93.0
2	17.6	60.6	78.9	41.8	102.3
3	18.5	58.9	78.1	53.4	112.3
4	30.1	56.9	87.1	15.3	72.2
5	23.2	60.6	85.4	35.9	96.5
6	28.3	57.8	86.6	23.0	80.8
7	24.6	56.6	81.4	28.2	84.7
8	23.7	59.3	83.1	29.0	88.3
9	20.5	58.0	78.7	38.6	96.6
10	22.7	57.8	81.1	24.6	82.4
11	17.8	56.1	73.9	42.7	98.8
12	28.1	61.6	89.7	32.6	94.2
13	19.8	58.3	78.6	26.7	85.0
Total	23.3	58.4	82.2	32.8	91.3

subjects by center ranged from 32.3 to 56.1%, and the cost calculation places lower weight on the time costs of unemployed persons. Second, the distribution of occupation classes differed between centers, across the range 29.4 to 53.6% manual workers, and nonmanual workers' opportunity cost of time is higher (owing to higher wages). Third, the average distance traveled by screening center ranged from 7.9 to 31.2 miles, longer distances entailing higher time and travel costs. Fourth, the intercenter variation in the proportion of those attending alone ranged between 11.2 and 55.1%, and unaccompanied visits imply lower opportunity cost, compared to when two persons are attending. In contrast, factors such as the gender composition of the sample and mode of transport accounted for only a small proportion of cost variations.

The second column of Table 3 provides estimates of the direct NHS costs of FS screening, per person screened. As the intercenter variability is accounted for only by the differential rate of repeat sigmoidoscopy, the range about the average is small. The third column lists the total direct costs of FS screening, per person screened. These estimates comprise direct NHS costs and private costs. It is assumed that additional private costs will be incurred by subjects requiring a repeat sigmoidoscopy on a different day. As may be seen, center 11 achieved the lowest cost per person, by virtue of requiring both a low number of repeat investigations and low private costs. The reverse is the case for center 12.

The fourth column of Table 3 reports each center's NHS costs of all postscreening management per subject, comprising the costs of all events beyond the initial screening sigmoidoscopy. It is evident that the range of costs exceeds the mean, and this high variability is explicable in large part by the variation in center-specific yield. Distal adenomas or cancers were detected in 12% of subjects for the trial as a whole, although the yield by center varied between 9 and 15% (1). Finally, the fifth column presents the average NHS costs of the full FS program of screening and management, i.e., the costs of the screening sigmoidoscopy plus those of all subsequent investigations and treatments which subjects received (but excluding long-term surveillance). The difference between highest and lowest cost is £40.0 (43% of the trial mean), and the distribution has a standard deviation of 10.3.

It should be recalled that these costs estimates have been based on the assumption of common unit costs for procedures after screening sigmoidoscopy. Were this assumption to

be relaxed, a further source of variation would emerge. Procedure-specific data by hospital are unavailable, as noted earlier, although the NHS reference cost archive for England and Wales (10) does include estimates for how specific hospitals' costs (averaged across all activities) depart from the national average. For the English and Welsh centers in the trial, the departures range from 12% below (center 10), to more than 20% above (center 4), the national mean. We believe that using these departures as multiplying factors in a mechanical manner would be misleading. They are completely nonspecific with respect to procedure, although they do serve to highlight a potential further source of variability. This having been said, the effect of such a mechanical adjustment appears unpredictable. Despite representing the range of variation in terms of average overall costs, the two centers specified above are actually amongst the lower cost centers with respect to FS, as indicated in Table 3.

The primary purpose of undertaking this costing analysis was to inform a cost-effectiveness analysis of once-only sigmoidoscopy screening as a method for preventing colorectal cancer. A true cost-effectiveness estimate is impossible at present, however, as we await the trial's effectiveness data. These data will be obtained from the long-term (ten years and beyond) follow-up of both the test and the control groups. However, our cost information can be readily translated for more immediate use, namely, to estimate the likely total costs of FS screening, were the trial protocol to be applied in a national setting. For the sake of simplicity, we assume 100% compliance with screening in these estimates—lower compliance rates would lower costs pro rata. The number of UK persons aged 60 years is approximately 572,000. Combining this estimate with the data obtained, namely, the total screening sigmoidoscopy cost per person, by center (Table 3), the proportion requiring colonoscopy, by center (Table 2), the unit cost of colonoscopy and the private costs associated with clinic visits (Table 3), we obtain center-specific estimates in the range £46.4 million (center 11) to £56.2 (center 12) million per annum. The mean estimate is £52.5 million (SD 2.9). Considering NHS costs alone, the range becomes £35.9 million (center 11) to £42.0 million (center 3), about a mean of £38.4 million (SD 1.9).

This figure can usefully be compared with an estimate for the costs of colorectal cancer screening using fecal occult blood (FOB) testing (49). The Nottingham trial of FOB testing (52) offered biennial testing to subjects aged between 50 and 74 years, and followed up positive test results with endoscopic or radiological investigations. The expected cost of FOB screening using the Nottingham protocol, when translated into current prices, emerges as £7.0 per person screened. The estimation method appears comparable with that of FS above, in that it too embodies test, investigation, and private costs. The UK population in the eligible 50–74 years of age range is approximately 12.5 million. As half of these people would be screened in any one year, the total annual screening cost amounts to approximately £44 million.

As the FOB trial was conducted at a single site, no estimates of intercenter variation for this protocol are possible. It is also important to note that, within the FOB protocol, private costs were minimal. They were incurred only during visits for investigation, as subjects received the FOB test by mail. In contrast, around 27% of the gross cost of the FS protocol comprised privately incurred time and travel costs, on average. As a result, the total NHS costs of the FS protocol are slightly lower than those of the FOB protocol.

Neither of these two estimates allows for any centrally organized population call/recall system (as operates with UK cervical cancer screening, for example), nor do they include the cost of managing the abnormalities detected, beyond endoscopic excision. The relative costs of the two protocols cannot be translated into relative cost-effectiveness as, compared with FOB, the FS protocol yielded a higher rate of abnormalities detected, especially with respect to adenomas. As noted above, the extent to which abnormality detection translates into survival advantage remains to be assessed. This having been said, the cost-effectiveness of the lower-yielding FOB protocol has already been demonstrated (53).

Table 4. Recent Flexible Sigmoidoscopy Cost Estimates (£, 2000)

Investigators	Reference	Year	Country	Type	Cost
Walker et al.	50	1991	UK	Audit	42
Geul et al.	17	1997	Netherlands	Audit[a]	66
Wagner et al.	48	1991	USA	Tariff	87
Norum	34	1998	Norway	Tariff	95
Lewis and Asch	24	1999	USA	Audit	107
Lewis et al.	25	2002	USA	Tariff	139
Vijan et al.	47	2001	USA	Tariff	156
Bolin et al.	7	1999	Australia	Tariff[a]	181
Cromwell et al.	9	1998	USA	Tariff[a]	185
Frazier et al.	14	2000	USA	Audit	189
Wallace et al.	51	1999	USA	Audit	192
Khandker et al.	21	2000	USA	Claims	225
Suleiman and Sonnenberg	44	2001	USA	Tariff[a]	249
Sonnenberg et al.	42	2000	USA	Claims	262
Marshall et al.	30	1996	USA	Tariff	270
Helm et al.	18	2000	USA	Claims	300

[a]Pathology/biopsy explicitly excluded.

DISCUSSION

As is evident from Table 3, the unit cost of the FS procedure itself dominates the overall costs of a once-only FS screening program: the cost of FS represents, on average, around 61% of overall NHS costs per person entailed by screening. We believe that this cost dominance justifies our decision to undertake a detailed audit of the procedure within the trial, rather than to rely on estimates produced by other investigators. Having undertaken such an exercise, it is illuminating to compare our estimate of around £56 per with other recent estimates, as presented in Table 4. To facilitate comparison, all published estimates have been translated into sterling from the local currency, using the current purchasing power parity exchange rate, and converted to 2000 prices.

In addition to identifying the studies, the year of publication, and the country for which the estimates pertain, Table 4 classifies the method of cost estimation. Three main techniques have been used. First, some studies used insurance claims data to compute costs, suggesting that cost could be represented by the average amount of money actually paid out by health insurance organizations to reimburse the procedure. Second, some studies took costs to be the tariffs stated in the schedules of fees and allowances published by professional associations and insurance organizations. Third, some studies undertook audits (of the form undertaken in this study), constructing the procedure cost from accounts of actual resource use, disaggregated by type (e.g., labor, equipment, disposables used). It should be noted that all these estimates are for sigmoidoscopy as a procedure rather than as a screening tool and, thus, typically do not include screening administration costs.

The variation in these estimates is considerable (approximately sevenfold), and there are three potential explanations for this finding. First, we should anticipate differences in resource costs specifically between countries, given differences in factor prices. On this basis alone, we should expect the U.S. estimates to be higher than those derived elsewhere. Second, the wide range of the U.S. results is explicable in terms of varying disparities between charges and costs by provider (13), the large number of individual third-party payers in that country, and the differing degrees of local competition amongst service providers. The U.S. sigmoidoscopy studies cited have used data from a range of different payers in different regions. Examples include Maryland Blue Cross (9), Medstat, Washington (18;21),

and Group Health Cooperative, Seattle (14). Some U.S. studies used national Medicare averages (25;47), although other authors indicated only that they had derived their costs from "local sources" (30). Even greater variability has been identified in a North American study of an analogous procedure (screening colonoscopy), which detected an eighteen-fold variation in charges between hospitals (36).

The third possible explanation emerges when we compare our results with an earlier UK cost audit (50), which yielded slightly lower unit costs for sigmoidoscopy. It is the transparency of this earlier study that allows us to explain the difference. The administrative component in the earlier study was less significant and technical change has evidently occurred. In the earlier study, high-grade labor used relatively low-cost optical instruments, whereas the Flexi-Scope trial entailed intermediate-grade labor using high-cost videoscopes. In the earlier study, clinical labor accounted for 42% of variable costs, whereas capital consumption accounted for only 4%. Comparison of these proportions with those of Table 1 suggests that flexible sigmoidoscopy has become more "capital-intensive" over the past decade.

Technical change, of course, does not remain static. For example, recent studies have investigated the possibility of nurse practitioners undertaking sigmoidoscopy in a primary care setting (35;39;41). Were such a model to prove acceptable in a future screening context, it might be expected to reduce further both NHS clinic costs (as nurses are typically less costly than physicians) and private costs (as primary care is typically more accessible to screening subjects than are hospital-based clinics).

Finally, it has been argued that multicenter evaluations are likely to yield superior estimates to those derived from single-center studies (8). In comparison with the latter, the former can identify cost and outcome variability and, thus, prove more valuable when generalizing the findings of the study to other settings. Our own results clearly indicate that, even with a tightly specified protocol and common unit costs, considerable intercenter variation in average costs can occur. In our case, variations can be ascribed primarily to center-specific private costs and different modes of subject management after the detection of abnormalities. Coupled with variability in yield by center, the impact on intermediate cost-effectiveness will be amplified.

POLICY IMPLICATIONS

Realistic cost estimates of flexible sigmoidoscopy are a vital basis for predicting the likely resource costs of implementing a national screening program using this procedure. On the basis of the evidence presented, it would appear that neither the FS nor the FOB protocol offers a particular cost advantage in the UK. Realistic cost estimates are also a necessary precursor to calculating the cost-effectiveness of FS screening, to establish whether such costs are indeed worth incurring.

Many European countries are presently seeking to develop policies for colorectal cancer screening. As policy based on evidence tends to be superior to that based on conjecture, realism in costs will make an obvious contribution in this respect. As noted earlier, the range of feasible protocols for colorectal cancer screening is very wide: there exist several individual screening tests that could be used alone or in combination, at varying time intervals and with different risk groups. Large-scale trials for each possible protocol would be prohibitively time-consuming and expensive. As the colorectal cancer disease process appears particularly amenable to mathematical modelling, screening simulations have proliferated (12;28;29;38;45), each aiming to assess the cost-effectiveness of screening protocols beyond those for which we necessarily have trial evidence. In making decisions about screening protocols, therefore, policy makers must weigh trial evidence alongside evidence from simulations.

Simulations will necessarily be populated with clinical and economic data imported from other sources, or they will simply use arbitrary or nominal values for illustrative purposes. The validity of the simulated results and, thus, their quality as a basis for policy relies very heavily on the cost and outcome values chosen as modeling inputs. The point at issue can be illustrated by considering just one of these simulations in which the modelers demonstrated that a screening protocol of sigmoidoscopy every five years, followed by colonoscopy where required, could actually yield overall cost savings in a U.S. health care setting, by virtue of the future cancer treatment costs avoided (29). The model assumed a "baseline" unit cost for sigmoidoscopy which appears to have been averaged from two published results, one an audit study (24) and one itself a nominal cost (28). It was observed, however, that the central proposition held only where unit sigmoidoscopy costs were lower than a dollar value equivalent to around £130. As is evident from Table 4, only two of the twelve U.S. estimates of sigmoidoscopy costs would actually enable the required criterion to be met. Appreciating the sensitivity of their conclusions to their assumptions about cost, the authors conclude that their "result underlines the need to investigate the true cost of sigmoidoscopy . . . " (p. 561).

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