BMJ

RESEARCH

Costs and cost effectiveness of different strategies for chlamydia screening and partner notification: an economic and mathematical modelling study

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Cite this as: *BMJ* 2010;341:c7250
doi:10.1136/bmj.c7250

ABSTRACT

Objectives To compare the cost, cost effectiveness, and sex equity of different intervention strategies within the English National Chlamydia Screening Programme. To develop a tool for calculating cost effectiveness of chlamydia control programmes at a local, national, or international level.

Design An economic and mathematical modelling study with cost effectiveness analysis. Costs were restricted to those of screening and partner notification from the perspective of the NHS and excluded patient costs, the costs of reinfection, and costs of complications arising from initial infection.

Setting England.

Population Individuals eligible for the National Chlamydia Screening Programme.

Main outcome measures Cost effectiveness of National Chlamydia Screening Programme in 2008–9 (as cost per individual tested, cost per positive diagnosis, total cost of screening, number screened, number infected, sex ratio of those tested and treated). Comparison of baseline programme with two different interventions—(i) increased coverage of primary screening in men and (ii) increased efficacy of partner notification.

Results In 2008–9 screening was estimated to cost about £46.3m in total and £506 per infection treated. Provision for partner notification within the screening programme cost between £9 and £27 per index case, excluding treatment and testing. The model results suggest that increasing male screening coverage from 8% (baseline value) to 24% (to match female coverage) would cost an extra £22.9m and increase the cost per infection treated to £528. In contrast, increasing partner notification efficacy from 0.4 (baseline value) to 0.8 partners per index case would cost an extra £3.3m and would reduce the cost per infection diagnosed to £449. Increasing screening coverage to 24% in men would cost over six times as much as increasing partner notification to 0.8 but only treat twice as many additional infections.

Conclusions In the English National Chlamydia Screening Programme increasing the effectiveness of partner notification is likely to cost less than increasing male coverage but also improve the ratio of women to men diagnosed. Further evaluation of the cost effectiveness of partner notification and screening is urgently needed. The spreadsheet tool developed in this study can be easily modified for use in other settings to evaluate chlamydia control programmes.

INTRODUCTION

Genital infection by *Chlamydia trachomatis*, is a common bacterial sexually transmitted infection.[1] Screening is intended to reduce chlamydia prevalence and reduce the incidence of long term complications. Modelling studies indicate that regular screening at moderate coverage could reduce chlamydia prevalence, but there is considerable uncertainty in these predictions.[2-4] There are no international guidelines on the optimal chlamydia screening strategy—consequently there are a range of screening programmes (targeted, opportunistic, or registry based) organised locally and nationally in developed nations.[1] In England an opportunistic National Chlamydia Screening Programme for sexually active individuals aged 15–24 years was launched in 2003.[5,6] Local delivery of this screening programme is currently assessed by attainment of an annual coverage target.[5] In 2008–9, 16% of the eligible population were screened (24% of women and 8% of men) at an average cost of £45 per test.[7,8]

Partner notification is an essential component of the management of all sexually transmitted infections, because of the high chance of infection in sexual partners. About two thirds of the sexual partners of patients who test positive for chlamydia are also found to be infected.[9,10] In England, 65% of male partners of chlamydia positive women were found to be infected, compared with 6% of men tested through primary screening in 2008–9.[8,11] Partner notification also reduces the risk of reinfection in the index patient.[11] At the population level, partner notification breaks current chains of transmission and prevents onward spread of infection. In most settings, more women

than men are screened for chlamydia,[12-15] so effective partner notification mitigates this sex inequity by increasing the proportion of men diagnosed and treated within the control programme. The reported efficacy of partner notification activities is highly variable across the 89 programme areas within the National Chlamydia Screening Programme.[6] In 2008–9, a median of 0.4 partners per index patient were confirmed treated (range 0.1–1), and only 25% of sites achieved the recommended level of 0.6 partners notified per index (0.4 in large urban areas).[6]

We present estimates of the cost of partner notification, based on a new analysis of data collected in the recent National Chlamydia Screening Programme costing guidance initiative.[16] We also developed a spreadsheet model for rapid assessment of screening and partner notification for chlamydia control (appendix 3 on bmj.com). We used this model together with the new estimates of the cost of partner notification to evaluate chlamydia control activities as reported in 2008–9. We then compared the cost effectiveness (using the cost per positive diagnosis) of two different interventions—increased coverage of primary screening in men and increased efficacy of partner notification. We hypothesised that the current focus on increasing primary coverage to 35% in 2010–1 could result in reduced cost effectiveness and increased sex inequity if coverage is prioritised at the expense of effective partner notification.

METHOD

The box summarises definitions we used in our analyses.

Definition of key terms

Partner notification (PN) efficacy

This is the average number of partners treated per index case. PN efficacy was calculated by dividing the number of partners confirmed as treated (PNt) by the total number of index cases (Ic) for each site: PN efficacy = PNt/Ic

This measure does not rely on accurate disclosure of the number of partners. Partners may or may not be tested. Confirmation of treatment may be by the clinician, other care provider, or the patient. For example, with 20 index cases and 10 out of 30 partners treated, the partner notification efficacy is 0.5 partners per index; with 20 index cases and 10 out of 20 partners, however, PN efficacy is still 0.5 per index.

Partner notification (PN) probability

The probability of treating reported partners was calculated as the proportion of reported partners (Pr) who were confirmed as receiving treatment (PNt): PN probability = PNt/Pr

Index case

An individual found to be chlamydia positive through opportunistic screening

Primary screen

Someone receiving opportunistic screening who is not (or is not known to be) a sexual contact of a case.

Screening coverage

The overall fraction of the target population who are screened. For example, if 500 out of 2000 denominator population are screened, the coverage is 25%.

Case finding efficiency (rate)

This is a measure of the chance of finding an infected individual. For example, if 10 people are tested and 1 person is infected the case finding efficiency is 10%.

Cost of partner notification and screening

Costs were available from a recent audit in sufficient detail for seven primary care trusts that achieved high ratings in the Vital Signs Index, which measured a variety of indicators.[7 16] We selected three of these as showing the range of partner notification strategies implemented within the National Chlamydia Screening Programme. These are defined as low, medium, and high intensity according to the level of provider resources invested in partner notification (details of the costs are given in table C in appendix 1 on bmj.com). The sites are not named, however, because evaluation of individual provider (primary care trust) practice is beyond the scope of this study. We also sought data from the Health Protection Agency on partner notification efficacy for these sites, which was reported as between 0.2 and 0.3 partners confirmed treated per index (table D in appendix 1). However, because of uncertainties in the quality of reporting data and discrepancies in the denominator population and in definitions of partner notification efficacy, we could not accurately map the numbers of partners reported as treated to the cost data. Instead, we used the reported range of partner notification efficacy across all sites (0.1–1 partner per index notified) in sensitivity analyses.

The specific cost of partner notification was calculated for each of the selected programme areas, using data collected for the National Chlamydia Screening Programme costing guidance initiative.[16] Further details of the costing method are provided in appendix 1. To overcome inconsistencies in the way data were summarised at the local level, we developed a consistent costing model from a healthcare provider perspective. Costs were collected from available data sources and through semistructured interviews conducted in 2008–9. The cost of partner notification was captured with a time process analysis extracted from several elements of the screening and partner notification pathway: time for discussion of partner notification during index client notification or clinician delivered treatment, provider referral by health professionals, and follow-up telephone calls (supported partner notification). The proportion of the cost of screening devoted to partner notification activities was also calculated and accounted for 3% of the total cost of a screen.

The average cost per screening episode for the seven primary care trusts was £45. For sensitivity analysis, we used £45 as the base case, with £33 (lowest estimated cost per screen, cost guidance) and £56 (average cost estimated by the National Audit Office report) as lower and upper bounds.[7 16] This includes all elements of screening, including partner notification for positive cases. To avoid this double counting, we calculated that partner notification accounts for 3% of the total screening cost, giving an adjusted average cost per screening episode excluding partner notification of £43.65 (£32.01–£54.32).

Toolkit for calculation of cost and cost effectiveness with a simple economic model

We developed a user friendly model as an Excel spreadsheet to calculate the cost and cost effectiveness of screening and partner notification. The input parameters are (for males and females) the number screened, positivity in those screened, proportion of positive cases from screening who are successfully treated, positivity in partners notified, cost of screening and cost of partner notification. Initial input parameter values are given in table A in appendix 1, based on the National Chlamydia Screening Programme annual report 2008–9 and the new costs of partner notification generated from our analysis.[8] A detailed description of the model calculations is given in table B, appendix 1. The input parameters can be readily updated to reflect control activities in other countries, improved empirical estimates, changes in coverage and partner notification efficacy over time or for evaluating and comparing local service delivery. (The spreadsheet and user guide are available as appendices 2 and 3 on bmj.com.)

The total cost of screening is assumed to be directly proportional to the volume of screening. Calculations of cost and cost effectiveness assume that, at baseline, the cost of a screen is £43.65 (with range based on lower and upper estimates of £32.01 and £54.32), excluding partner notification. The model was used to estimate the total cost of screening, the number screened and treated, the sex ratio of the people tested and treated, the number treated through partner notification, the cost per screen, and the cost per positive diagnosis by sex, under different assumptions about the cost and efficacy of partner notification. We used the model to compare the impact of increasing male coverage with increasing the effectiveness of partner notification. Sensitivity analysis was performed for a range of partner notification costs, partner notification efficacy, and male screening coverage.

RESULTS

The costs of providing partner notification per positive index case were £9, £13, and £27 for the low, medium, and high intensity settings. The breakdown of partner notification costs are presented for each of the selected areas in table C, appendix 1. These estimates do not include the cost of testing or treatment, so we assumed that the total additional cost would be no more than the average cost of screening a positive index case, which had been estimated to be £87. For the baseline analysis, we conservatively assumed that the cost of partner notification was the sum of the upper estimate of the cost of providing partner notification plus the average cost of treating a positive case—that is, £27 + £87 = £114. A range of values for total cost of partner notification were used in additional scenario analyses (£54–£395 per partner notification).[16]

Cost effectiveness of interventions

The baseline scenario (the figures reported by the National Chlamydia Screening Programme for 2008–9), which involves screening nearly one million individuals, costs approximately £46.3m (range £34.6m–£56.8m) in total and on average £506 (£381–£621) per infected individual treated (table). Calculations of cost and cost effectiveness assume that, at baseline, the cost of a screen is £43.65 (with range based on lower and upper estimates of £32.01 and £54.32), excluding partner notification. An estimated 72570 infections were diagnosed through primary screening, and 18868 infected individuals received treatment through partner notification. This is in broad agreement with the 26000 contacts actually reported in 2008–9, of whom 13000 were known to have been tested.[8]

Baseline model inputs and outputs for levels of screening and partner notification reported by the National Chlamydia Screening Programme for 2008–9

	Women	Men	Total
Target population (aged 15–24 years)	3 075 000	3 075 000	6 150 000
Coverage (%)	24	8	16
No of people screened	738 000	246 000	984 000
No of people diagnosed	56 826	15 744	72 570
No of people identified by partner notification:			
Who receive appropriate care*	6 298	22 730	29 028
Who are infected	4 093	14 775	18 886
Cost of screening and partner notification combined (£m)†	32.9	13.3	46.3
Cost per positive diagnosis (£)	540.6	436.8	505.9
Positivity (combined partner notification and screen) (%)‡	8.2	11.4	9.0
Proportion of prevalent infections treated (%)§	—	—	29.7
Proportion of total budget used for partner notification (%)	—	—	7.2
Ratio of women to men tested	—	—	2.77
Ratio of women to men infected and treated	—	—	2.0

See table A of appendix on bmj.com for details of baseline model assumptions.
*Based on partner notification efficacy of 0.4 (median value for screening programme).
†Based on cost of a screen of £43.65 and cost of partner notification of £114 (£27+£87).
‡Based on positivity of 7.7% in women and 6.4% in men screened, and of 65% in partners of positive index cases (men and women).
§Based on 5% prevalence in 15–24 year olds.

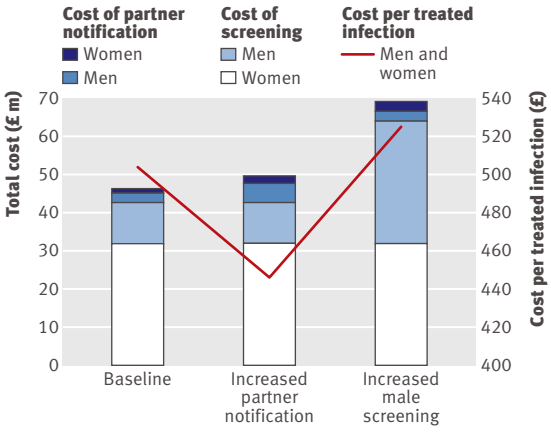

Fig 1 | Total cost of National Chlamydia Screening Programme (by partner notification costs and screening costs) and cost per positive case treated under different scenarios—baseline scenario (24% of eligible women and 8% of eligible men screened, median of 0.4 partners notified per index case), increased partner notification (0.8 partners notified per index case), and increased male screening coverage (24% of eligible men)

Figure 1 shows the estimated total cost of screening for the baseline scenario and for the proposed interventions. Increasing the efficacy of partner notification, from 0.4 to 0.8 partners treated per index case, reduces the sex ratio (female:male) of treatment of infected individuals from 2.0:1 to 1.4:1 and reduces the cost per infection treated from £506 to £449 (£345–£545). Conversely, increasing male coverage to 24% increases the cost per positive case treated to £528 (£397–£648).

Figure 2 shows the result of the sensitivity analysis to ascertain the impact of varying partner notification efficacy on the cost per positive case treated for different costs of partner notification.

Additional sensitivity analyses results are provided in appendix 1. The impact of varying the coverage of screening on the average cost per infection treated is shown in fig A, appendix 1. The effect of increasing the cost of partner notification linearly with increasing efficacy on the cost per infection treated is shown in fig B, appendix 1. Details of the outcomes and further scenario analyses are given in table E, appendix 1. We estimated that the cost of reaching 35% coverage, by screening 42% of women and 27% of men, would be £101m (£76m–£124m) per year and £517 (£389–£635) per infection treated.

DISCUSSION

Within the current National Chlamydia Screening Programme, partner notification is an underused but highly effective strategy for increasing treatment of infected individuals, particularly men. Partners of an infected index case may be up to 10 times more likely to be infected than an individual identified through primary screening. Some areas in the screening programme currently achieve 0.8 or more partners notified and treated per index case, and we show that, if achieved nationally, this rate would reduce the cost per positive diagnosis from £506 (range £381–£621, assuming low costs (£33) or high costs (£54) of screening) to £449 (£345–£545) and increase the number diagnosed by 21% (18868 diagnoses).

In contrast, increasing the screening coverage in men would increase the cost per positive diagnosis to £528 (£397–£648). Overall, increasing screening coverage would cost over six times as much as increasing partner notification but only treat twice as many additional infections (39675).

We estimated the cost of providing partner notification in three sites operating different partner notification pathways to range from £9 to £27, excluding the cost of treatment and testing. However, we were unable to link these costs directly to site specific estimates of partner notification efficacy because of concerns about the accuracy of the reported data (further details in appendix 1). Given the broad range of currently reported efficacy and range of strategies for providing partner notification services it is likely that high and low efficacy sites are run at similar cost, and also sites with similar efficacy are run at different cost. Further evaluation is urgently needed to determine a benchmark for good practice and value for money.

We assumed, conservatively, that the cost of partner notification was the same regardless of the efficacy achieved and used the upper estimate from the costing study, but in practice reaching partners of different types may have different cost implications for the provider: for example, notification of current regular partners (index led) is substantially cheaper than notifying past, casual partners (provider led). However, increasing partner notification costs with increasing efficacy had little impact on the cost per positive diagnosis compared with a constant cost because most of the cost is due to screening. A tiered classification of partner types should ideally be reflected in the cost estimates of partner notification. We also did not take into account the cost of partner notification which does not result in

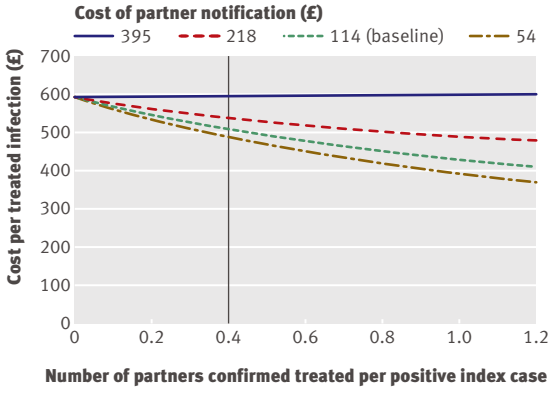

Fig 2 | Sensitivity analysis showing impact of increasing partner notification efficacy for different costs of partner notification in a chlamydia screening programme. The cost per screen is £43.65, and chlamydia positivity in partners notified is 65%. The y axis crosses at the baseline value (0.4 partners per index case)

partner treatment.

Strengths and weaknesses of the study

This analysis is based on current estimates of activity within the National Chlamydia Screening Programme and the associated costs incurred. We also undertook sensitivity analyses to show that the conclusions are robust to parameter assumptions and variation in costs or relative efficacy over a wide range of parameter choices. We have chosen a straightforward model framework, have used conservative assumptions, and considered only the direct effect of changing screening coverage and partner notification efficacy. The structure means that input values can easily be updated, such as with improved estimates of costs or effectiveness from subsequent years' results or adapted for local use by a primary care trust. The toolkit can also be easily modified for use in other settings such as evaluating chlamydia control programmes in other countries.

A limitation is that it is not possible to estimate long term cost effectiveness within this model framework. This would require a transmission dynamic model and new empirical data on the effectiveness of screening to update existing models. Existing models have made conflicting predictions of the likely impact of screening on prevalence.[17] However, we have estimated the proportion of prevalent infections treated as a result of the competing strategies, with a greater or lesser emphasis on primary screening compared with partner notification.

Definition and measurement of partner notification

Monitoring the outcomes of partner notification was identified as a key difficulty for services, with confusion over definition of outcome measures of partner notification and over denominator populations. We have tried as far as possible to use internally consistent estimates of cost and efficacy at the level of the primary care trust and to include a broad range of values in sensitivity analysis. We have used the number of partners of an index with known treatment or test as a measure of efficacy which may be confirmed by patient, partner, or clinician. The advantage is that it is related directly to the number of index cases.

Obtaining the necessary partner information and linking partner treatment back to the index case is usually done through a follow-up telephone call, recommended at two weeks after treatment.[18] This "best practice" pathway is shown in fig 3 and corresponds to model 3.[18] However, not all centres follow this protocol. Additionally, there may be discrepancies in how sites record details of partner notification outcomes for partners who have already received a test or treatment when an index case is screened. These sort of reporting biases may cause some diluting of the effectiveness of partner notification, but the overall cost and efficacy are likely to be within the values we used for our sensitivity analysis. Modern communication technologies such as automated text messaging and online and email notifications may contribute to better data management as well as improving partner notification outcomes and reducing the cost of these services.[19 20]

Comparison with previous research

The most effective and cost effective approach to partner notification within primary care has not yet been established. A study in Sweden that contacted partners in the past 18 months (compared with the 3 or 6 months in standard practice) achieved partner notification rates of up to 1.5 partners per index case.[8] A randomised controlled trial evaluating different models of partner notification is currently under way (HTA partner notification study, ISRCTN 24160819). Individuals who were found to be positive through primary screening through the National Chlamydia Screening Programme reported on average 1.4 partners. This is consistent with other studies of chlamydia screening, implying that there is considerable scope to increase the number of infected partners who receive appropriate care.[9 11 12 15 21 22]

Individuals diagnosed with chlamydia are at high risk of reinfection: 14% (range 0–32%) of index cases were reinfected within a year in 38 studies.[11] Successful partner notification is associated with a reduced risk of reinfection.[11 23 24] We did not include the indirect benefits of partner notification on reinfection or on complications, which would further improve the relative cost effectiveness of partner notification in our model.

Implications for policy

Compared with increasing coverage, partner notification identifies more chlamydia positive individuals for each unit of resource invested in a screening programme. There is considerable scope to improve partner notification outcomes. Furthermore, reallocation of resources to ensure provision and monitoring of effective partner notification is likely to result in substantial cost savings in comparison with increasing screening coverage only. It is not clear from the available data how much additional benefit should be expected from a given level of investment in partner

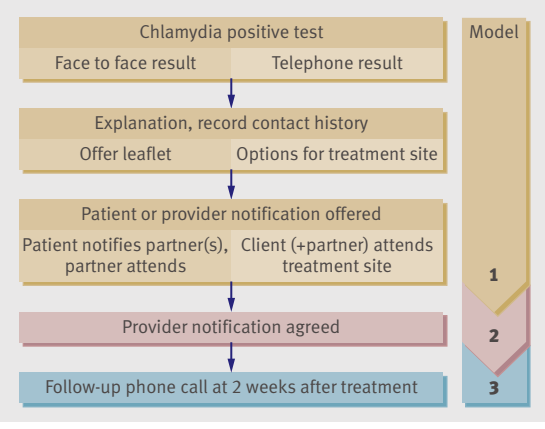

Fig 3 | Care pathway for partner notification (after National Chlamydia Screening Programme advisory group report[18]) showing the interventions offered by model 1, model 2, and the complete pathway, model 3

WHAT IS ALREADY KNOWN ON THIS SUBJECT

The National Chlamydia Screening Programme in England screens more women than men each year

Partner notification is an essential component of a screening programme, since 65% of the sexual partners of those diagnosed with chlamydia are also infected (compared with only 5–8% of those identified through screening)

WHAT THIS STUDY ADDS

The current cost of partner notification activities within the English National Chlamydia Screening Programme are estimated

A user friendly model has been developed that allows rapid evaluation of the cost and effectiveness of different chlamydia control programmes

Increasing the coverage of chlamydia screening without improving partner notification efficacy would be an inefficient use of resources

notification. The wide range of reported partner notification and the diverse methods of organisation make it difficult to generalise, and urgent evaluation is needed to establish the most cost effective approach to partner notification.

Equitable access to screening for men and women should continue to be promoted. However, the additional resources required to increase male screening coverage to reach equity with females would be more effectively employed in the short term in achieving high partner notification efficacy among those who test positive. Partner notification therefore mitigates the impact of sex inequity in screening coverage since the high proportion of partners infected offsets the lower number of men screened

Performance indicators must reflect quality and value for money of service provision, not just quantity of services provided. The spreadsheet tool we have developed will enable local services to evaluate their own programmes and allow rapid updates based on national reports. This tool could also be adapted for use in other countries. We provide strong evidence for the cost effectiveness of partner notification in identifying infected cases compared with screening alone. The number of infected individuals (women and men) identified through a screening programme is arguably a more appropriate metric for assessing the success of screening than primary coverage by sex.

Key message

Partner notification is an essential component of a screening programme and could be used as an indicator of service quality. Improving partner notification efficacy not only reduces the cost per positive case identified compared with increasing screening coverage alone but also improves sex equity in access to treatment for those infected. Future planning of chlamydia control could include measures to increase coverage such as sex specific targets of coverage based on current patterns of attendance and uptake of screening services, together with renewed focus on achieving measurable, high partner notification rates.

We thank Johanna Riha, from the National Chlamydia Screening Programme (NCSP) team and Health Protection Agency, for providing data on the reported efficacy of partner notification for selected sites. We also thank Marie Kernec (Health Protection Agency) and Vikki Pearce, who worked on the NCSP costing guidance initiative.

Contributors: KT and PH conceived the initial idea for the paper. KT planned the analysis, designed the model, and planned and wrote the first draft of the paper. PH informed the model and planning of the study and contributed to writing and revising the paper. EA and AG provided the cost data for partner notification pathways, undertook the economic analysis, and advised on the model. JM advised during initial planning and input into model development. JC advised on the model, particularly in relation to NCSP data and management. GB advised on partner notification strategies and provided data on partner notification pathways and her experience of providing partner notification in practice. All authors had full access to all of the data (including statistical reports and tables) in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis, and have critically revised the first draft and reviewed and approved the submitted and revised manuscripts

Funding: This work was supported by a grant from the Bristol Sexual Health Centre Capacity Building Research Fund. KT is supported by an NIHR PDF fellowship. KT and GB also received funding from the NIHR Health Technology Assessment programme (project number 07/42/02). All authors in this paper are independent of their funders for publication purposes. The views and opinions expressed here are those of the authors and do not necessarily reflect those of the funders.

Competing interests: JC, PH, and JM are board members of the National Chlamydia Screening Advisory Group of the Department of Health and receive expenses for travel to meetings. JC also receives compensation for secondment as chair on NCSAG paid directly to Leeds Hospital Teaching Hospitals Trust. AG and EA received consultancy fees from Bristol Sexual Health Centre Capacity Building Research Fund for the additional cost data analysis and travel to a meeting with the other authors. EA and AG did consultancy work for the NCSP in spring 2009 on a project to estimate the cost of chlamydia screening. KT received consultancy fees from Bristol Sexual Health Centre Capacity Building Research Fund for additional days worked to develop the model and write the paper outside funded time. KT and EA were previously employed by the Health Protection Agency to work on economic and mathematical models of the impact of chlamydia screening. PH collaborated in a multicentre evaluation of a new molecular diagnostic test for chlamydia and gonorrhoea by Siemens Healthcare Diagnostics, for which his department received funding.

Ethical approval: No approval was required for this study

Data sharing: The excel spreadsheet, user guide, and dataset are provided in the appendices on bmj.com and are available from the corresponding author (katy.turner@bristol.ac.uk).

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Accepted: 4 October 2010