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Title: A cost-effectiveness analysis of condom distribution programs for the prevention of sexually transmitted infections in England

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30

31 **Competing Interest**

32 Susi Sadler: None declared.

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44

45 **Structured Abstract**

46 **Background**

47 Prevention of sexually transmitted infection (STI) incidence in England is a high priority,
48 particularly among young people, men who have sex with men (MSM) and black ethnic
49 minorities. An economic evaluation of condom distribution programs (CDPs) to reduce STI
50 transmission is presented.

51 **Methods**

52 An economic model using a Bernoulli Process estimated the number of people acquiring an
53 STI as a function of its prevalence, transmission rate, condom use, condom failure rate, and
54 number of sexual contacts. Models were developed for young people (13-24 years), black
55 ethnic minorities, MSM and the general English population. Effectiveness evidence came
56 from a recent systematic review. For young people, a CDP was modelled (relative risk for
57 condom use=1.23), along with an exploratory analysis of the impact on unintended
58 pregnancies. For other populations, threshold analyses were used to identify the
59 combination of costs and effect-size required to make a program cost-effective.

60 **Results**

61 The base case predicted that CDP for all young people in England could avert 5,123 STI
62 cases per annum, with an incremental cost-effectiveness ratio of £17,411. In addition, it
63 could avert 118 pregnancies and 82 abortions and save £333,000 in associated costs.
64 Schemes for black ethnic minorities and MSM could also be cost-effective even with
65 relatively high costs and small effect-sizes.

66 **Conclusion**

67 CDPs for young people are likely to be cost-effective or cost-saving. CDPS for other high-
68 risk populations may also be cost-effective if they can increase condom use, since high HIV
69 prevalence in these groups imposes a considerable health and cost burden.

70

71 **Thumbnail Sketch**

72 **What is already known on this subject?**

73 435,000 sexually transmitted infections were diagnosed in England in 2015, with substantial
74 year-on-year increases in syphilis and gonorrhoea. Incidence was particularly high in young
75 people under the age of 25, men who have sex with men and black ethnic minorities.

76 Condom distribution programs provide condoms free or at reduced prices, sometimes with
77 training or support, to try and increase condom use and prevent the spread of sexually
78 transmitted infections.

79 A recent systematic literature review highlighted a paucity of relevant evidence evaluating
80 the cost-effectiveness of condom distribution programs in the UK.

81

82 **What this study adds?**

83 An economic model to evaluate the cost-effectiveness of condom distribution programs was
84 developed. It suggested that an intervention which provides free condoms along with some
85 education and support to young people in England could be expected to avert 5,123 new
86 sexually transmitted infections per annum. This would lead to improved health-related quality
87 of life and treatment cost savings, resulting in an estimated incremental cost of £17,411 per
88 quality-adjusted life-year gained compared with no program.

89 Condom distribution programs for men who have sex with men and black ethnic minorities
90 may also be cost-effective even with small increases in condom use since these groups
91 have higher prevalence of HIV, which has a big impact on life-expectancy, quality of life and
92 treatment costs.

93

94 **Introduction**

95 Sexually transmitted infections (STIs) have detrimental impacts on quality of life and survival
96 and impose a burden on the UK National Health Service (NHS). In 2015 there were 435,000
97 new diagnoses in England with a 20% and 11% increase observed in the incidence of
98 syphilis and gonorrhoea respectively compared with 2014 (2). STI incidence is highest
99 among people under the age of 25, men who have sex with men (MSM) and black ethnic
100 minorities (2).

101 Condoms can protect against transmission of many STIs including gonorrhoea, chlamydia,
102 syphilis and HIV (3). The 2014-15 increase in syphilis and gonorrhoea diagnoses is
103 attributed to high levels of unprotected sex (2). Reasons condoms are not used or are used
104 incorrectly include cost, lack of knowledge and social norms. Condom distribution programs
105 (CDPS) aim to overcome these challenges by providing condoms free of charge or at
106 reduced prices, possibly accompanied by training or support, such as the C-Card program
107 (the multi-component program most commonly offered to young people in England) (4).

108 The Department of Health referred the topic "Sexually transmitted infections: condom
109 distribution schemes" to the National Institute for Health and Care Excellence (NICE) to
110 develop public health guidance (5). NICE considers evidence for effectiveness and cost-
111 effectiveness in developing recommendations. A systematic literature review highlighted a
112 paucity of evidence for the cost-effectiveness of condom distribution programs in the UK (6).
113 Therefore, we developed an economic model to evaluate the cost-effectiveness of CDPs.
114 This study presents our economic evaluation of CDPs for the general population and for
115 targeted at-risk groups: young people, MSM, and black ethnic minorities.

116

117 **Methods**

118 **Population**

119 We based the population on English 2011 census data by gender and five-year age-group
120 (7). Cohorts of the appropriate age-range and gender were selected to model each of the
121 target groups.

122 **Model**

123 We developed an economic model which estimated 'steady state' STI acquisition and
124 associated cost-effectiveness. The model uses an established Bernoulli Process which
125 estimates the number of STIs in a cohort of people (8) and has been used in other economic
126 evaluations, including NICE Public Health guidelines (10, 11). The model predicts the
127 proportion of people acquiring an STI in a given gender- and age-specific group (W) as a
128 function of the STI prevalence (v), the proportion of sexually active people using condoms
129 (g), the STI transmission rate (t), the condom failure rate (k), and the annual number of
130 sexual contacts in that subgroup (s):

$$W = v \left(g(1 - ((1 - tk)^s)) \right) + \left((1 - g)(1 - ((1 - t)^s)) \right)$$

131 The impact of a CDP was captured by changing the proportion of people using condoms (g)
132 according to the effectiveness of the intervention while all other parameters were held
133 constant. Outputs were total STI cases averted, quality-adjusted life years (QALYs) gained,
134 costs and cost-effectiveness (cost per QALY gained).

135

136 **Effectiveness**

137 NICE's systematic review searched for evidence of effectiveness, in terms of changing
138 condom use, of single-component programs (free provision of condoms), multi-component

139 programs (provision of condoms along with some sort of education or advice element) and
140 cost-price condom provision programs between 1996 and 2015 (6) and identified 20 studies.
141 Three studies were of multi-component programs in young people. These reported relative
142 risks of 1.11 (95% CI=0.94-1.32) for condom use at last intercourse (Furstenberg *et al.* (12)),
143 1.13 (1.04-1.22) for condom use at last intercourse (Guttmacher *et al.* (13)) and 1.23 (1.10-
144 1.38) for ever having used a condom (Larsson *et al.* (14)). Evidence quality varied, with
145 Furstenberg *et al.* and Guttmacher *et al.* reporting quasi-experimental and pre-and post-
146 intervention evaluations, whereas Larsson *et al.* reported a controlled trial. The studies were
147 located in the US (Furstenberg, Guttmacher) and Sweden (Larsson). No studies evaluated
148 interventions in the UK. The review concluded that there was some limited evidence to show
149 that multi-component programs in high schools can increase condom use. The highest
150 quality study (14) was chosen to give the estimated effectiveness in the base case (also the
151 study with the largest effect size). It is worth noting that the population (students aged 17)
152 and intervention (school-based) used in this trial was not a perfect match for the C-card
153 program, which targets a broader age-range (typically ages 13-24) and in a wider range of
154 settings (including sexual health, genito-urinary medicine clinics, youth services and
155 schools). The base case uses an age range of 13-24 to replicate C-card. However, since the
156 evidence is taken from a younger population, a scenario for ages 13-18 years is also
157 presented.

158 The review identified one study targeting black ethnic minorities (15). This study was located
159 in the USA and targeted those with high levels of syphilis. It reported that condom use
160 increased, although study quality was poor and data were not presented.

161 The review identified one single component program targeting MSM. However, this study did
162 not ask about condom use at last anal intercourse and despite improvements in condom
163 possession rate, a small increase in men saying they 'had anal intercourse without a
164 condom simply because there was no condom available' was reported (16).

165 The review identified only one study looking at reduced-price condom provision (17).
166 Although this study showed increased condom purchasing, no data were collected on
167 condom use.

168 Due to the lack of effectiveness evidence for programs for black ethnic minorities, MSM and
169 the general population via discounted provision, a threshold analysis was carried out for
170 these groups assessing a range of effectiveness and cost levels, to identify the combination
171 of costs and effectiveness required to make a program cost effective at a threshold of
172 £20,000 per QALY gained, or dominant (QALY-improving and cost-saving). £20,000 per
173 QALY is the notional threshold used by NICE to assess whether interventions are
174 considered cost-effective if funded by the NHS.

175 **QALYs**

176 QALY loss was modelled either using an absolute QALY reduction per STI obtained from the
177 literature or a disutility per STI multiplied by time affected. For HIV Farnham *et al.* (18) was
178 used, assuming people were diagnosed when their CD4 count was above 500, and
179 including QALYs lost due to infections and reduced life-expectancy, with a 3% annual
180 discounted rate, this being a US study. All QALY decrements are shown in Table 1.

181 [INSERT TABLE 1]

182 **STIs**

183 The STIs modelled are chlamydia, gonorrhoea, syphilis, human immunodeficiency virus
184 (HIV) and pelvic inflammatory disease (PID), which can follow chlamydia or gonorrhoea in
185 women. Prevalence of chlamydia, gonorrhoea and syphilis by risk group, age and gender
186 were taken from Public Health England (PHE) cases in 2014 (19). HIV prevalence was
187 based on new cases from PHE (20). Prevalence estimates are shown in Table 1.

188 [INSERT TABLE 2]

189 **Other parameters**

190 Table 1 contains all the parameters of the STI model. Age and gender-specific proportions of
191 people who are sexually active and rates of sexual contact were taken from Mercer et al.
192 (21), with under-13s assumed not to be sexually active. The percentage of men who are
193 MSM (2.8%) was taken from the National Survey of Sexual Attitudes and Lifestyles (22).

194 Age-specific rates of routine condom use for young people, black ethnic minorities and the
195 general population were reported by the Office of National Statistics (20), with under-16s
196 assumed the same as 16-19 year-olds. MSM condom use was taken from the 2008 UK Gay
197 Men's Sex Survey (23) and applied across all ages. Condom failure rate was based on
198 Macaluso et al. (24).

199 Evidence on the probability of transmission per unprotected sexual contact is old and limited
200 by the ethical implications of this research. Rates and sources are presented in Table 1.

201 Rates of PID as a function of the number of cases of chlamydia and gonorrhoea were based
202 on two studies (25, 26).

203

204 **Costs**

205 We used an NHS and personal social services perspective, a cost year of 2015 and a 3.5%
206 annual discount rate. All costs are shown in Table 1. We include in STI treatment costs the
207 appropriate number of consultations, tests and treatments using the British National
208 Formulary (BNF) (27) and unit costs of health and social care (28). Costs of PID were taken
209 from a previously published report. (11). The UK lifetime HIV treatment cost was taken from
210 Nakagawa et al, (29) using the more conservative of their two estimates (based on the
211 assumption of switching to generic drugs once pharmaceutical patents expire, and assuming

212 generic drugs cost 20% of the branded versions). It was thought important to use the more
213 conservative estimate here to avoid potentially overestimating the costs.

214 A rapid search identified intervention costs for five local C-card programs in England and
215 Wales (30-34). Using published population statistics for ages 13-24 for each area (7), we
216 calculated that four of the five programs gave costs between £0.33 and £0.68 per head of
217 teenage population per annum (the other had higher costs of £1.21 per head). An estimated
218 cost of £0.48 (95% CI=£0.19-£0.76) per head of teenage population was chosen as the
219 average of the four lowest-cost published programs. This cost was validated using a bottom-
220 up costing exercise informed by experts with experience of running programs.

221

222 **Uncertainty**

223 A probabilistic sensitivity analysis (PSA) of 5,000 runs was conducted to assess the impact
224 of parameter uncertainty on the model output. All results presented are probabilistic.

225 The systematic review identified three studies of multicomponent programs in young people.
226 In our base case we used the highest-quality study, but this also had the largest effect size
227 (RR=1.23). As a sensitivity analysis we calculated the incremental cost effectiveness ratio
228 (ICER) associated with a condom use relative risk of 1.11 (the lower effect size from the
229 three studies).

230 There is reasonable evidence in the literature that condom failure rates reduce with
231 experience (35). A scenario was modelled for young people which assumed reduced
232 condom breakage (odds ratio of 0.8) based on Macaluso *et al.* (24).

233 Base-case HIV prevalence estimates are from diagnosis rates and may underestimate the
234 true prevalence of HIV. Therefore, higher HIV prevalence scenarios were modelled using
235 estimated HIV prevalence by risk group from the 2015 HIV Situation Report (36) and in

236 addition using updated figures for MSM in London (20). In the general population a scenario
237 used rates from the NICE HIV testing guideline (10).

238 To validate our model we compared our results for young people, with and without a CDP, to
239 the 2014-2015 PHE data for STI prevalence (37).

240 The focus of NICE's guideline was STIs. However, an exploratory analysis was undertaken,
241 to understand the impact of the interventions in young people aged of 14–18 years upon
242 pregnancy, using an existing model of contraceptive interventions (38) and assuming that all
243 pregnancies within this age group were unintended. It was assumed that 50% of the
244 unintended teenage pregnancies would be prevented and 50% delayed until age 19-24. The
245 probability of becoming pregnant and of having an abortion by age were updated using the
246 latest national statistics (39). The model was updated to use the same condom failure rate
247 as the STI model. Costs were expressed in 2014/15 prices (40).

248

249 **Results**

250 Results for young people aged 13-24 are summarised in Table 3. The analysis predicts that
251 an intervention with effectiveness taken from Larsson et al. (14) and with costs in the region
252 of a typical C-card program would be expected to avert 5,123 cases of STIs (95% CI=439-
253 12,441), of which over 4,200 (30,655-85,406) are chlamydia. The program is estimated to
254 lead to a gain of 55 (14-136) QALYs and a positive net cost (program cost minus healthcare
255 savings) of £957,622 (-£2,723,496-£2,947,501), giving an incremental cost per QALY gained
256 of £17,411 compared with no CDP.

257 The evidence for effectiveness was for a younger age group, however. With age 13-18 years
258 only, the program was not cost-effective at NICE's £20,000 level (ICER = £45,856).

259 The result was sensitive to reducing the effectiveness estimate. With a reduced change in
260 condom use ($R=1.11$), the ICER in the 13-24 age group increased to £88,979. The results of
261 the scenario analysis where condom breakage was reduced led to an ICER of £14,469. In
262 the scenario with higher HIV prevalence the increase in HIV cases averted makes the
263 program cost-saving overall (£10m healthcare savings compared with £3.5m program costs
264 across England in the target population).

265 [INSERT TABLE 3]

266 In an additional exploratory analysis of pregnancy outcomes, an England-wide program with
267 base case costs and effectiveness is predicted to avoid approximately 118 pregnancies, 82
268 abortions and save £333,000 across England in associated costs (not included in our
269 presented results). This would increase to £12m if government funded benefits were
270 included.

271 Figure 1 illustrates the results of threshold analyses for the base case in each population.

272 The result show that CDPs are much more likely to be cost-effective in populations with high
273 prevalence of HIV (MSM and black ethnic minorities), and that even programs with relatively

274 small effect sizes and high costs can be cost-saving in these groups. Meanwhile, programs
275 for young people can be cost-effective or cost-saving as long as costs can be controlled to
276 around 40-60p per person, depending on effectiveness. Untargeted programs for the general
277 population are only likely to be cost-effective at very low cost.

278 [INSERT FIGURE 1]

279 Results of model validation are shown in Figure 2. The model correctly shows a decrease in
280 chlamydia diagnoses, although it overestimates this decrease by approximately 40%.
281 Similarly the model overestimates the decrease in gonorrhoea diagnoses, which actually
282 increased among 20-24 year old males. Syphilis remains fairly constant in both the model
283 and PHE data, except the model shows a small decrease in cases for 20-24 year old males
284 and PHE data shows an increase.

285 [INSERT FIGURE 2]

286

287 **Discussion**

288 The cost-effectiveness of CDPs is heavily influenced by the underlying STI prevalence and
289 sexual activity levels of the population.

290 We found that the ICER for CDP targeted at young people, such as the C-Card program was
291 likely to be cost-effective at NICE's £20,000/QALY threshold. Threshold analyses suggest
292 that CDPs for MSM and black ethnic minorities can also be cost-effective even if the
293 program cost per person is fairly high, whereas for the general population in which
294 prevalence and risk of transmission are lower, costs have to be very low in order for
295 programs to be cost-effective.

296 HIV prevalence is particularly important in determining cost-effectiveness. This is because
297 although HIV is relatively less prevalent than other STIs, the cost and QALY loss per case is
298 much higher. Our study confirms findings (41, 42) that CDPs for populations with high HIV
299 prevalence can be cost-effective when condom usage is increased by as little as 2%
300 (RR=1.02).

301 Although the focus of NICE's guidance was STI prevention, our analysis suggests that
302 including the potential impact on reduced conception rates makes it very likely that a CDP
303 would be cost-saving. This analysis was somewhat speculative, especially in terms of
304 government-funded benefit costs, since the benefits landscape has changed considerably
305 since the original model was developed in 2010.

306 This is the first study to estimate the cost-effectiveness of CDPs in the UK. It combines data
307 from several different sources, and gives an indication of the potential economic impact of C-
308 Card programs which has not previously been reported. However, the analysis is limited by
309 the quality and availability of evidence. It assumes that all sexually active people within one
310 age band behave in the same way, with an average number of sexual contacts and the
311 same probability of condom use without a CDP. In reality there will be some people who are

312 more sexually active than others, some people in monogamous relationships and some with
313 higher numbers of sexual partners, and condom usage rates will differ according to these
314 (and other) factors.

315 Validating the binomial model of disease prevalence is challenging because the current
316 distribution and uptake of CDPs in England are unknown, and because CDPs are often
317 linked to other services such as STI testing which impact diagnosis rates and confound
318 prevalence estimates. We expected the model results without CDP to show more STIs than
319 the PHE 2015 data, and the model results with CDP to show fewer STIs than the PHE 2015,
320 since in reality a number of CDPs programs are already in operation. We saw that for all
321 STIs, the model results with and without STIs were lower than the PHE data. The binomial
322 model of steady state disease prevalence appears therefore to underestimate STI
323 transmission and therefore potentially underestimates the effect of increased condom usage
324 on STI reduction, which suggests that the estimates of CDP cost-effectiveness are likely to
325 be conservative.

326 We used a static model for estimating the transmission of STIs, assuming a constant
327 underlying prevalence of each STI. In reality, for STIs with long recovery periods or no
328 recovery, the underlying prevalence will increase. This may partly explain why our model
329 under-predicts STI prevalence. This effect may be particularly important in the case of HIV,
330 for which both costs and quality of life effects are high. In addition, our model does not take
331 account of the potential transmission of infections such as HIV and syphilis from mother to
332 baby, where condom use before and during pregnancy may have the additional impact of
333 reducing infection or other severe health impacts on foetuses or new-borns.

334 Our model was not able to account for any effects of increased condom use on undiagnosed
335 STIs. There may also be variability around CDP costs. We used the average from four C-
336 Card programs with similar costs as these closely corresponded to a bottom-up costing
337 exercise, and excluded one program that had higher costs.

338 Our model considers STI transmission over a one-year period, which may underestimate the
339 benefit of CDPs for two reasons. Firstly, since new STI diagnoses are a function of initial
340 prevalence, the rates of new diagnoses for CDP and a comparator without CDP, diagnoses
341 would be expected to diverge over time and the incremental effectiveness would increase.
342 Secondly, there may be longer term benefits of engaging people with CDPs and sexual
343 health services, potentially resulting in fewer STIs at little or no extra cost.

344 More research of better quality is needed on the effectiveness of CDPs. Research that
345 investigates change in condom usage would also allow the economic models to be updated,
346 while research investigating the relationship between CDP implementation and STI
347 incidence would remove the need for an epidemiological model. Evaluations of C-Card
348 programs are particularly important to understand both their effectiveness and cost-
349 effectiveness. Furthermore, comparative evaluation of different modes of implementation of
350 C-Card programs and different population subgroups or age groups would allow policy
351 makers to understand how these programs may be optimally delivered and targeted.

352 We conclude that CDPs for young people are likely to be good value for money at currently
353 accepted cost-effectiveness thresholds, and that CDPs for other high-risk populations may
354 also be economically attractive. Given the substantial public health burden associated with
355 STIs, it is important that efforts are made to reduce their transmission and this suggests that
356 CDPs are likely to be a cost-effective approach.

357

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369 out the literature review which contributed to the work.

370

371 **Tables/Illustrations:**

372 *Table 1 Costs (£), QALYs and STI transmission parameters and distributions used in the*
 373 *model*

	Mean	Range	Source	
COSTS (£) DIAGNOSIS AND TREATMENT				
Chlamydia	121.92	Max = 75.76 Min = 166.58	(28) (44) (45)	
Gonorrhoea	206.17	Max = 129.24 Min = 280.61	(28) (44) (45)	
Syphilis	210.59	Max = 133.66 Min = 285.03	(28) (44) (45)	
HIV	103,243	95% CI = 82,594 - 123,892	(29)	
PID	3,124	95% CI = 2499 - 3749	(11) (28)	
COSTS (£) INTERVENTION				
C-card per head (age 13-24)	0.48	95% CI = 0.34 - 0.62	(30, 32-34)	
QALYs				
Chlamydia	-0.002	-	(46)	
Gonorrhoea	-0.004	-	(46)	
HIV	-6.200	95% CI = -7.950 - -4.450	(18)	
Syphilis	-0.006	95% CI = -0.0068 - -0.0055	(47)	
PID	-0.025	-	(48)	
Parameter	Value	Distribution (α,β) Rounded (unless specified)	Source	
SEXUAL PRACTICE – CONDOM USE (By age)				
16-19	54%	None	(49)	
20-24	54%		(49)	
25-29	41%		(49)	
30-34	46%		(49)	
35-39	27%		(49)	
40-44	10%		(49)	
45-49	13%		(49)	
MSM (All ages)	52.7%		(23)	
CONDOM BREAKAGE				
Rate	3.6%	Beta (194, 9,704)	(24)	
SEXUALLY ACTIVE – MEN				
13	4.4%	Beta (1,007, 320)	NATSAL-3	
14	11.8%		dataset (21)	
15	26.0%		(21)	
16-24	75.9%		(21)	
25-34	90.1%		Beta (952, 105)	(21)
35-44	92.5%		Beta (682, 55)	(21)
45-54	86.4%		Beta (68, 11)	(21)
55-64	76.3%		Beta (533, 166)	(21)
65-	59.8%		Beta (336, 226)	(21)
SEXUALLY ACTIVE – WOMEN				
13	2.3%		Beta (1,246, 372)	NATSAL-3
14	8.5%	dataset (21)		
15	21.4%	(21)		
16-24	77.0%	(21)		
25-34	91.8%	Beta (1,698, 152)		(21)
		(21)		

35-44	90.8%	Beta (850, 86)	(21)
45-54	85.0%	Beta (990, 175)	(21)
55-64	63.7%	Beta (519, 296)	(21)
65-	42.1%	Beta (266, 365)	(21)
SEXUAL CONTACTS – MEN			
13-15	5.10	Gamma (0.50, 10.16)	assumed
16-24	5.10	Gamma (0.50, 10.16)	(21)
25-34	5.40	Gamma (0.69, 7.82)	(21)
35-44	4.10	Gamma (0.91, 4.51)	(21)
45-54	4.10	Gamma (0.45, 9.08)	(21)
55-64	3.20	Gamma (0.51, 6.33)	(21)
65-	2.30	Gamma (0.41, 5.63)	(21)
SEXUAL CONTACT – WOMEN			
13-15	5.80	Gamma (0.77, 7.51)	assumed
16-24	5.80	Gamma (0.77, 7.51)	(21)
25-34	4.90	Gamma (0.92, 5.31)	(21)
35-44	4.00	Gamma (0.76, 5.29)	(21)
45-54	3.50	Gamma (0.69, 5.04)	(21)
55-64	2.50	Gamma (0.54, 4.62)	(21)
65-	1.40	Gamma (0.37, 3.78)	(21)
PID RATES			
after chlamydia	16.0%	Beta (9, 47)	(25)
after gonorrhoea	0.9%	Beta (4, 469)	(50)
TRANSMISSION RATES			
HIV – Men	0.120%	Beta (10, 8,175)	(51)
HIV - MSM	1.400%	Beta (6, 394)	(52)
HIV – Women	0.390%	Beta (5, 1,324)	(51)
Chlamydia	45.000%	Beta (42, 52)	(53)
Gonorrhoea	53.000%	Beta (16, 14)	(53)
Syphilis	61.818%	Beta (68, 42)	(54)

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Table 2: Mean prevalence values used in the model for Chlamydia, Gonorrhoea, HIV & Syphilis

Age group	Chlamydia		Gonorrhoea		HIV						Syphilis	
					Low (Base case)		Central		High			
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
YOUNG PEOPLE & GENERAL POPULATION												
13 – 14	0.009%	0.136%	0.001%	0.010%	0.004%	0.001%	-	-	0.054%	0.019%	0.000%	0.000%
15 – 19	0.881%	2.651%	0.101%	0.166%	0.016%	0.006%	-	-	0.229%	0.081%	0.004%	0.002%
20 – 24	1.800%	2.692%	0.330%	0.161%	0.015%	0.005%	-	-	0.209%	0.072%	0.022%	0.003%
25 – 34	0.704%	0.631%	0.292%	0.055%	0.042%	0.014%	-	-	0.586%	0.195%	0.036%	0.003%
35 – 44	0.205%	0.120%	0.143%	0.015%	0.033%	0.011%	-	-	0.471%	0.155%	0.035%	0.001%
45 – 64	0.057%	0.023%	0.041%	0.004%	0.017%	0.006%	-	-	0.243%	0.079%	0.014%	0.000%
65+	0.006%	0.001%	0.004%	0.000%	0.004%	0.001%	-	-	0.053%	0.014%	0.001%	0.000%
MSM												
13 – 14	0.026%	-	0.011%	-	0.000%	-	0.000%	-	0.000%	-	0.000%	-
15 – 19	1.705%	-	1.240%	-	0.464%	-	4.732%	-	8.605%	-	0.088%	-
20 – 24	5.911%	-	6.548%	-	0.424%	-	4.321%	-	7.859%	-	0.629%	-
25 – 34	5.595%	-	7.539%	-	1.241%	-	12.657%	-	23.019%	-	1.116%	-
35 – 44	3.443%	-	4.101%	-	0.728%	-	7.421%	-	13.496%	-	1.104%	-
45 – 64	1.125%	-	1.113%	-	0.311%	-	3.175%	-	5.774%	-	0.435%	-
65+	0.124%	-	0.081%	-	0.030%	-	0.305%	-	0.554%	-	0.026%	-
BLACK ETHNIC MINORITIES												
13 – 14	0.015%	0.231%	0.003%	0.028%	0.231%	0.641%	0.284%	0.759%	0.369%	0.881%	0.000%	0.000%
15 – 19	1.491%	4.485%	0.286%	0.469%	0.987%	2.752%	1.214%	3.261%	1.579%	3.784%	0.006%	0.003%
20 – 24	3.044%	4.554%	0.932%	0.454%	0.901%	2.457%	1.108%	2.911%	1.442%	3.378%	0.037%	0.005%
25 – 34	1.192%	1.067%	0.826%	0.157%	2.524%	6.634%	3.105%	7.861%	4.039%	9.122%	0.061%	0.005%
35 – 44	0.346%	0.203%	0.403%	0.041%	2.026%	5.297%	2.492%	6.277%	3.242%	7.283%	0.060%	0.002%
45 – 64	0.096%	0.039%	0.117%	0.010%	1.046%	2.696%	1.287%	3.195%	1.674%	3.707%	0.024%	0.001%
65+	0.010%	0.001%	0.011%	0.000%	0.228%	0.492%	0.280%	0.583%	0.364%	0.676%	0.002%	0.000%

Table 3 Results of modelling the C-card program in young people for the whole eligible population of England

Scenario	STIs averted					Total	STI cost savings	Program cost	Net cost	QALY gain	Cost/QALY
	Chlamydia	Gonorrhoea	HIV	Syphilis	PID						
Base case (age 13-24)	4272	378	6	14	454	5123	£2,587,340	£3,544,962	£957,622	55	£17,411
1: Age 13-18	1151	83	2	2	135	1373	£758,947	£1,538,499	£779,552	17	£45,856
2: Lower RR condom use	2007	178	3	7	215	2409	£1,216,794	£3,530,260	£2,313,466	26	£88,979
3: Breakage reduced	4586	407	5	15	487	5501	£2,728,775	£3,539,033	£810,258	56	£14,468
4: High HIV prevalence	4254	376	77	14	454	5174	£9,954,650	£3,541,896	-£6,412,754	496	Dominates

Figure 1 Threshold analyses showing cost per QALY gained from the base-case analysis across a range of program costs (per person per annum) and effectiveness levels (relative risk of condom use) in a) young people b) MSM c) black ethnic minorities and d) general population

Figure 2: Validation results

FIGURES SUBMITTED SEPARATELY

References

1. Lucas S. Unprotected Nation: The Financial and Economic Impacts of Restricted Contraceptive and Sexual Health Services. 2013.
2. Public Health England. Sexually transmitted infections and chlamydia screening in England. 2015.
3. Public Health England. Condoms and STDs: Fact Sheet for Public Health Personnel. 2013.
4. Public Health England, Brook. C-Card condom distribution schemes Why, what and how. 2014.
5. National Institute for Health and Care Excellence. Guideline Scope, Sexually transmitted infections: condom distribution schemes. . 2015.
6. Carmona C, Kavanagh J, Cullum A, Shaw T, Murray A. Sexually transmitted infections: condom distribution schemes, effectiveness and costs-effectiveness evidence review 2016. Available from: <https://www.nice.org.uk/guidance/GID-PHG93/documents/evidence-review>
7. 2011 Census: Population estimates by single year of age and sex for local authorities in the United Kingdom [Internet]. 2011 [cited 17.04.2016]. Available from: <https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/2011censuspopulationestimatesbysingleyearofageandsexforlocalauthoritiesintheunitedkingdom>.
8. Pinkerton S, Abramson P. Evaluating the Risks A Bernoulli Process Model of HIV Infection and Risk Reduction. *Evaluation Review*. 1993;17(5):504-28.
9. Sukthankar A. Syphilis. *Medicine*. 2010;38(5):263-6.
10. NICE. Contraceptive services for under 25s. 2014.
11. Nherera L, Jacklin P. A model to assess the cost-effectiveness of Sex and Relationship Education (SRE) developed for NICE public health guidance on personal, social, health and economic (PSHE) education. National Collaborating Centre for Women's and Children's Health; 2009.
12. Furstenberg FF, Jr., Geitz LM, Teitler JO, Weiss CC. Does condom availability make a difference? An evaluation of Philadelphia's health resource centers. *Fam Plann Perspect*. 1997;29(3):123-7.
13. Guttmacher S, Lieberman L, Ward D, Freudenberg N, Radosh A, Des Jarlais D. Condom availability in New York City public high schools: relationships to condom use and sexual behavior. *Am J Public Health*. 1997;87(9):1427-33.
14. Larsson M, Eurenus K, Westerling R, Tyden T. Evaluation of a sexual education intervention among Swedish high school students. *Scand J Public Health*. 2006;34(2):124-31.
15. Ross MW, Chatterjee NS, Leonard L. A community level syphilis prevention programme: outcome data from a controlled trial. *Sex Transm Infect*. 2004;80(2):100-4.
16. Weatherburn P. Distribution of free condom packs via gay commercial venue in London: An evaluation of 'Rubberstuffers' pilot scheme. *Sigma Research*; 1998.
17. Dahl DW, Gorn GJ, Weinberg CB. Encouraging use of coupons to stimulate condom purchase. *Am J Public Health*. 1999;89(12):1866-9.
18. Farnham P, Gopalappa C. Updates of lifetime costs of care and quality-of-life estimates for HIV-infected persons in the United States: late versus early diagnosis and entry into care. *JAIDS Journal of Acquired Immune Deficiency Syndromes*. 2013.
19. Public Health England. Sexually transmitted infections (STIs): annual data tables. In: Public Health England, editor. 2014.
20. Public Health England. Inequalities in sexual health: Update on HIV and STIs in men who have sex with men in London. 2016.
21. Mercer C, Tanton C, Prah P, Erens B. Changes in sexual attitudes and lifestyles in Britain through the life course and over time: findings from the National Surveys of Sexual Attitudes and Lifestyles. *The Lancet*. 2013.
22. Sonnenberg P, Clifton S, Beddows S, Field N, Soldan K, Tanton C, et al. Prevalence, risk factors, and uptake of interventions for sexually transmitted infections in Britain: findings from the

- National Surveys of Sexual Attitudes and Lifestyles (Natsal). Lancet (London, England). 2013;382:1795-806.
23. Sigma Research. The UK Gay Men's Sex Survey (part of EMIS - the European MSM Internet Sex survey) London School of Hygiene & Tropical Medicine.; 2010 March 2011.
 24. Macaluso M, Kelaghan J, Artz L, Austin H, Fleenor M, Hook EW, 3rd, et al. Mechanical failure of the latex condom in a cohort of women at high STD risk. *Sex Transm Dis.* 1999;26(8):450-8.
 25. Price MJ, Ades AE, De Angelis D, Welton NJ, Macleod J, Soldan K, et al. Risk of pelvic inflammatory disease following Chlamydia trachomatis infection: analysis of prospective studies with a multistate model. *American journal of epidemiology.* 2013;178:484-92.
 26. Goller JL, De Livera AM, Fairley CK, Guy RJ, Bradshaw CS, Chen MY, et al. Population attributable fraction of pelvic inflammatory disease associated with chlamydia and gonorrhoea: a cross-sectional analysis of Australian sexual health clinic data. *Sex Transm Infect.* 2016.
 27. Joint Formulary Committee. British National Formulary. 69 ed. London: BMJ Group and Pharmaceutical Press; 2015.
 28. Curtis L, Burns A. Unit Costs of Health and Social Care 2015 Personal Social Services Research Unit; 2015.
 29. Nakagawa F, Miners A, Smith CJ, Simmons R, Lodwick RK, Cambiano V, et al. Projected Lifetime Healthcare Costs Associated with HIV Infection. *PloS one.* 2015;10:e0125018.
 30. Jablonskas S. Nottinghamshire Condom Card ("C Card") Distribution Scheme Department of Health; 2010.
 31. Lambeth Southwark and Lewisham. Sexual Health Strategy 2014-2017. 2014.
 32. Lincolnshire County Council Children's Services in Partnership with NHS Lincolnshire. C Card Condom Scheme – Evaluation. 2010.
 33. Newcastle & North Tyneside Health Promotion Department. C-Card Condom Distribution Scheme Newcastle and North Tyneside 2000.
 34. Varley E. Report of the findings of the review of Derbyshire sexual health services (Health and Communities) DERBYSHIRE COUNTY COUNCIL 2014.
 35. Frezieres RG, Walsh TL, Nelson AL, Clark VA, Coulson AH. Evaluation of the efficacy of a polyurethane condom: results from a randomized, controlled clinical trial. *Fam Plann Perspect.* 1999;31(2):81-7.
 36. Skingsley A, Yin Z, Kirwan P, Croxford S, Chau C, Conti S, et al., editors. HIV in the UK – Situation Report 2015: data to end 2014. November 2015; London.
 37. England PH. New STI diagnoses & rates by gender, sexual risk & age group, 2011-2015. 2016.
 38. Pilgrim H, Payne N, Chilcott J, Blank L, Guillaume L, Baxter S. Modelling the cost-effectiveness of interventions to encourage young people, especially socially disadvantaged young people, to use contraceptives and contraceptive services NICE; 2010.
 39. Abortion statistics, England and Wales [Internet]. 2014. Available from: <https://www.gov.uk/government/statistical-data-sets/abortion-statistics-england-and-wales-2014>.
 40. Consumer Price inflation time series dataset [Internet]. 2016 [cited 17.04.2016]. Available from: <https://www.ons.gov.uk/economy/inflationandpriceindices/datasets/consumerpriceindices>.
 41. Bedimo AL, Pinkerton SD, Cohen DA, Gray B, Farley TA. Condom distribution: a cost-utility analysis. *Int J STD AIDS.* 2002;13(6):384-92.
 42. Holtgrave DR, Maulsby C, Kharfen M, Jia Y, Wu C, Opoku J, et al. Cost-utility analysis of a female condom promotion program in Washington, DC. *AIDS Behav.* 2012;16(5):1115-20.
 43. Pilgrim H, Payne N, Chilcott J, Blank L, Guillaume L, Baxter S. Modelling the cost-effectiveness of interventions to encourage young people, especially socially disadvantaged young people, to use contraceptives and contraceptive services. 2010.
 44. Department of Health. Reference costs 2013-14. 2014.
 45. NICE. HIV testing: increasing uptake among people who may have undiagnosed HIV. 2016.

46. Turner K, Round J, Horner P. An early evaluation of clinical and economic costs and benefits of implementing point of care NAAT tests for Chlamydia trachomatis and Neisseria gonorrhoea. *Sexually transmitted infections*. 2013.
47. Tuite AR, Burchell AN, Fisman DN. Cost-effectiveness of enhanced syphilis screening among HIV-positive men who have sex with men: a microsimulation model. *PloS one*. 2014;9:e101240.
48. Looker KJ, Wallace LA, Turner KME. Impact and cost-effectiveness of chlamydia testing in Scotland: a mathematical modelling study. *Theoretical biology & medical modelling*. 2015;12:2.
49. Lader D, Hopkins G. Contraception and sexual health: a report on research using the National Statistics Omnibus Survey produced on behalf of the NHS information centre for. Office for National Statistics; 2008.
50. Goller J, Fairley C, Bradshaw C, De Livera A, Chen M, Guy R, et al. Risk of pelvic inflammatory disease from chlamydia and gonorrhoea among Australian sexual health clinic attendees. *ISSTD Conference 2015*.
51. Boily M-C, Baggaley RF, Wang L, Masse B, White RG, Hayes RJ, et al. Heterosexual risk of HIV-1 infection per sexual act: systematic review and meta-analysis of observational studies. *The Lancet Infectious Diseases*. 2009;9:118-29.
52. Baggaley RF, White RG, Boily MC. HIV transmission risk through anal intercourse: systematic review, meta-analysis and implications for HIV prevention. *Int J Epidemiol*. 2010;39(4):1048-63.
53. Wang L, Davis M. Economic evaluation of Safer Choices: a school-based human immunodeficiency virus, other sexually transmitted diseases, and pregnancy prevention. *JAMA Pediatrics*. 2000.
54. Alexander LJ, Schoch AG. Prevention of syphilis: Penicillin Calcium in Oil and White Wax, USP, Bismuth Ethylcamphorate and Oxophenarsine Hydrochloride in Treatment, During. *Archives of Dermatology*. 1949.