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Implementation of a national smoke-free prison policy: an economic evaluation within the Tobacco in Prisons (TIPs) study

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ABSTRACT

Objective To determine the cost-effectiveness of a smoke-free prison policy in Scotland, through assessments of the trade-offs between costs (healthcare and non-healthcare-related expenditure) and outcomes (health and non-health-related non-monetary consequences) of implementing the policy.

Design A health economic evaluation consisting of three analyses (cost-consequence, cost-effectiveness and cost-utility), from the perspectives of the healthcare payer, prison service, people in custody and operational staff, assessed the trade-offs between costs and outcomes. Costs associated with the implementation of the policy, healthcare resource use and personal spend on nicotine products were considered, alongside health and non-health outcomes. The cost-effectiveness of the policy was evaluated over 12-month and lifetime horizons (short term and long term).

Setting Scotland's national prison estate.

Participants People in custody and operational prison staff.

Intervention Implementation of a comprehensive (indoor and outdoor) smoke-free policy.

Main outcome measures Concentration of secondhand smoke, health-related quality of life (health utilities and quality-adjusted life-years (QALY)) and various non-health outcomes (eg, incidents of assaults and fires).

Results The short-term analyses suggest cost savings for people in custody and staff, improvements in concentration of secondhand smoke, with no consistent direction of change across other outcomes. The long-term analysis demonstrated that implementing smoke-free policy was cost-effective over a lifetime for people in custody and staff, with approximate cost savings of £28 000 and £450, respectively, and improvement in health-related quality of life of 0.971 QALYs and 0.262, respectively.

Conclusion Implementing a smoke-free prison policy is cost-effective over the short term and long term for people in custody and staff.

INTRODUCTION

People in custody (PiC) disproportionately come from deprived communities, where smoking rates are around four times higher than the most affluent areas.[1 2] Globally, smoking prevalence in prisons is around two to eight times higher than in the general population.[3] A 2017 survey in Scotland showed that smoking rates among PiC in Scottish prisons were reported to be 68%,[4] almost four times higher than that of the Scottish general population.[5] This high smoking prevalence contributes to poor health, directly among PiC who smoke, and indirectly among PiC and prison staff through exposure to secondhand smoke (SHS).[6]

Legislation on smoke-free public places substantially reduces SHS exposures[7 8] and improves health outcomes for smokers and those previously exposed to SHS.[6 9] Expanding smoke-free policies to prison settings may similarly improve the health of prison staff and PiC and has been shown to reduce numbers of smoking relating deaths for PiC.[7] This improvement in health may reduce health inequalities for PiC and likely reduce expenditure for health services. There is also potential for PiC to benefit financially if they are no longer purchasing tobacco. However, these policies could conversely result in additional costs, such as provision of smoking cessation support and responding to adverse outcomes should serious unrest occur.

Prior to the introduction of the smoke-free policy (hereafter referred to as 'the policy'), PiC were able to purchase tobacco products from the prison shop (canteen), including rolling and pipe tobacco, cigarettes, lighters, filters, papers and rolling machines. Electronic cigarettes (e-cigarettes), chargers and e-liquids became available for purchase from canteen lists 2 months prior to the implementation of the policy and have remained available since then. In addition, e-cigarette starter packs were available free of charge, for a limited period, to eligible smokers entering custody. Where possible, PiC who do not use e-cigarettes are not allocated to share a cell with an e-cigarette user. Prison staff and visitors to prisons in Scotland have not been permitted to smoke (or vape) on prison premises for many years.

While limited evidence on the health benefits of smoke-free prison policies exists,[7 10] there is none relating to the cost-effectiveness of these policies.[3 11] This paper reports an economic evaluation of introducing a smoke-free prison policy in Scotland, conducted as part of the Tobacco in Prisons (TIPs) study, which was the first multimethod, multiphase evaluation of its kind across a national prison system. TIPs findings on SHS levels

in prisons partially informed the Scottish Prison Service's (SPS) decision to implement the smoke-free policy.[12]

The aim of this health economic evaluation was to determine the cost-effectiveness of a smoke-free prison policy, compared with the absence of such a policy, through assessments of the trade-offs between costs (healthcare and non-healthcare expenditure) and outcomes (non-monetary health and non-health consequences).

METHODS

In health economic evaluations, a cost-utility analysis (using a health-related quality of life outcome) is typically conducted to assess the trade-off between costs and outcome of an intervention and inform decision makers. However, in public health interventions, impacts of the intervention often go beyond health. In line with the National Institute for Health and Care Excellence (NICE) recommendations on broadening approaches to evaluating public health interventions,[13] the health economic evaluation consisted of three complementary analyses (table 1): (1) cost-consequence analysis to capture broader impacts of the policy beyond a single health outcome measure, (2) cost-effectiveness analysis to determine the value of the policy on the reduction of SHS, a key outcome in the TIPs study, and (3) cost-utility analysis to determine the value of the policy on health-related quality of life and benchmark against NICE's current cost-effectiveness threshold of £20 000 per quality-adjusted life-year (QALY) gained.

Cost-consequence analysis

The cost-consequence analysis, based on the perspectives of the National Health Service (NHS), SPS, PiC and prison staff, was used to assess the impact of the policy on a broad range of relevant outcomes (beyond the usual QALY outcome). The changes in costs and relevant outcomes, between the three phases of TIPs (preannouncement, preparatory and post implementation; figure 1) were evaluated to capture transitional impacts across the entire study period, and are presented in a balance sheet format.[14]

Tobacco in Prisons

TIPs was a natural experiment based on a wide range of bespoke and routine data collected pre-implementation and post implementation of the smoke-free policy in November 2018. Findings on SHS exposures, dispensed medication and the views and experiences of PiC and prison staff, including on the introduction, use and sale of e-cigarettes in the lead up to implementation, are reported in detail elsewhere.[12 15–26] Data collected in the TIPs study were used to inform this analysis. The populations included were PiC and operational prison staff in Scottish prisons. Operational staff (hereafter referred to as 'staff') are based in areas of the prisons (most notably residential halls) where, prior to the policy, they would be exposed to SHS during working hours. Non-operational staff were excluded as they are unlikely to have been regularly exposed to SHS at work.

The Scottish prison estate comprises 14 closed and one open prison. Where the data allowed, only PiC in closed prisons were included in the analysis because PiC in Scotland's open prison can spend time in the wider community (eg, for work or for home visits) where they have access to tobacco. However, staff at the open prison were included in the analysis as they are affected by the policy during the working day. Information on the range of costs and outcomes that were available separately for the open and closed prisons is included in online supplemental appendix 1.

Resource measurement and valuation

Resource use categories were healthcare and personal nicotine use. We were unable to collect data on implementing the policy (intervention costs). Healthcare resource use associated with general practitioner (GP) and nurse visits was derived from TIPs surveys completed by PiC and staff, which provided mean estimates for each of the three phases of the study period.[17 18 26] For PiC, routinely collected data (monthly) from SPS and NHS National Services Scotland (NSS) were used to estimate resource use associated with secondary healthcare, including new outpatient visits (receiving treatment in hospital but not requiring an overnight stay), inpatient stays (receiving treatment in hospital requiring an overnight stay), mental health hospital stays (receiving treatment requiring an overnight stay at a mental healthcare unit), accident and emergency visits, ambulance use and dispensed medication for nicotine dependence and smoking-related illness; detailed analysis is described elsewhere.[19]

Unit costs were applied to all healthcare resource use to calculate direct medical costs, except for the cost of PiC medications which were included in the relevant NHS NSS routine data. All costs are reported in 2017/2018 pound sterling (GBP).

Detailed information on resource use data identification, sources, formats and unit costs is reported in online supplemental appendix 2.

PiC personal spend, at a monthly level, associated with tobacco use and e-cigarette products was derived from a complementary Cancer Research United Kingdom (CRUK)-funded analysis of prison canteen data. Mean personal spend associated with staff tobacco use for each of the three phases of the study was derived from TIPs surveys.

Outcome measurement and valuation

All outcomes expected to be impacted by the policy implementation were determined a priori in consultation with the broader TIPs research team. These included SHS levels, prisoner and staff health-related quality of life and non-health outcomes.

SHS levels were measured as part of the TIPs study at three time points using fixed-site monitoring of fine particulate matter ($PM_{2.5}$) concentrations inside prisons; details are published elsewhere.[12 15 16] $PM_{2.5}$ is an air pollutant widely accepted as a proxy for indoor SHS levels.[16]

Health-related quality of life was measured using the five-level Euro-Qol-5D (EQ-5D-5L) questionnaires included in the TIPs surveys at three time points. The EQ-5D-5L measures health-related quality of life through five domains: mobility, self-care, usual activities, pain/discomfort and anxiety/depression. Responses were mapped to the EQ-5D-3L using a mapping algorithm,[27] as recommended by NICE,[28] to estimate individual health utilities, which are bounded between '0' (representing death) and '1' (representing full health).

Non-health outcomes include incidents of assaults (prisoner on staff and prisoner on prisoner), number of deaths in custody, incidents of fires and number of PiC included in the Management of an Offender at Risk due to any Substance (MORS) policy. (The MORS policy supports staff to provide appropriate management and care to those suspected of being at risk due to any substance.) These outcomes were recorded at monthly intervals. Further information on outcomes, their sources and formats is available in online supplemental appendix 3.

Table 1 Summary of evaluation methods

Type of economic evaluation	Costs/outcomes	Justification for inclusion	Sources	Cost-effectiveness measure
Cost-consequence analysis comparing three phases (preannouncement vs preparatory vs post implementation)	**Costs (healthcare and personal spend on nicotine products)**			No cost-effectiveness measure presented—balance sheet format presenting disaggregated costs and outcomes
	GP/nurse visits (PiC and staff)	Potential for change with reduced exposure to tobacco/SHS (eg, for coughs and colds)	TIPs surveys of PiC and staff (all three phases)	
	Outpatient visits (PiC only)	Potential for change with reduced exposure to tobacco/SHS for smoking-related diseases	NHS NSS (ISD SMR00) (June 2016 to November 2019)	
	Inpatient stays (PiC only)	Potential for change with reduced exposure to tobacco/SHS for smoking-related diseases (eg, stays for cardiovascular events and respiratory disease)	NHS NSS (ISD SMR01) (June 2016 to November 2019)	
	Mental health stays (PiC only)	Potential for change with no licit access to tobacco, which could impact levels of distress	NHS NSS (ISD SMR04) (June 2016 to November 2019)	
	Accident and emergency (PiC only)	Potential for change with reduced exposure to tobacco/SHS for smoking-related diseases (eg, acute health events) and with no licit access to tobacco (eg, violence, including self-harm)	NHS NSS (ISD Unscheduled Care A&E2) (June 2016 to November 2019)	
	Ambulance (PiC only)	Potential for change with reduced exposure to tobacco/SHS for smoking-related diseases (eg, acute health events) and with no licit access to tobacco (eg, violence, including self-harm)	Scottish Prison Service (June 2016 to November 2019)	
	Medication—nicotine dependence and smoking-related illness (PiC only)	Potential for change with reduced exposure to tobacco/SHS (need for medication for smoking-related diseases), and with no licit access to tobacco (need for nicotine dependence products)	National Procurement, NHS NSS (June 2016 to November 2019)	
	Tobacco products (PiC and staff)	PiC—expected decrease when unavailable in canteen after implementation; staff—potential change in spend if influenced by policy	PiC—SPS canteen purchase data (3 months prior to implementation); staff—TIPs staff survey all three phases	
	E-cigarettes (PiC only)	Expected increased use with no licit access to tobacco in later phases	SPS canteen purchase data (3 months prior to implementation and 1 year after)	
	Outcomes (health and non-health related)			
	Concentration of secondhand smoke ($PM_{2.5}$)	Expected reduction due to policy implementation	TIPs study measurements (in all three phases)	
	Health-related quality of life—health utilities (PiC and staff)	Potential for change for PiC and staff due to reduced exposure to SHS and no licit access to tobacco	TIPs surveys for PiC and staff included a Euro-Qol-5D (EQ-5D) questionnaire (in all three phases)	
	Prisoner-on-staff assaults	Potential for change with no licit access to tobacco later in preparatory and post implementation phases	Scottish Prison Service (November 2017 to November 2019)	
	Prisoner-on-prisoner assaults	Potential for change with no licit access to tobacco later in preparatory and post implementation phases	Scottish Prison Service (November 2017 to November 2019)	
	All-cause mortality (deaths in custody—PiC)	Potential for change with reduced exposure to tobacco/SHS for smoking-related diseases	Scottish Prison Service (June 2016 to November 2019)	
	Fires	Potential for change due to no lighters permitted after implementation and frustration at no licit access to tobacco	Scottish Prison Service (June 2016 to November 2019)	
	Management of an Offender at Risk due to any Substance (MORS) policy	Potential for change with no licit access to tobacco and with the introduction of e-cigarettes in prisons	Scottish Prison Service (June 2016 to November 2019)	
Cost-effectiveness analysis comparing absence and presence of smoke-free policy (preannouncement to post implementation phases)	**Costs**—total of all costs included in cost-consequence analysis	Potential for change due to absence of licit tobacco—details above	Various sources—details above	Incremental cost per 10 µg/m^3 reduction in $PM_{2.5}$
	Outcome—concentration of secondhand smoke ($PM_{2.5}$)	Expected reduction due to policy implementation	TIPs study measurements (in all three phases)	
Cost-utility analysis comparing absence and presence of smoke-free policy (preannouncement to post implementation phases)	**Costs**—total of all costs included in cost-consequence analysis	Potential for change due to absence of licit tobacco—details above		Incremental cost per quality-adjusted life-year
	Outcome—quality-adjusted life-years (PiC and staff)	Potential for change for PiC and staff due to reduced exposure to SHS and no licit access to tobacco	TIPs surveys for PiC and staff included an EQ-5D questionnaire (in all three phases) combined with 12-month time period	

A&E, accident and emergency; GP, general practitioner; ISD SMR, Information Services Division Scottish Morbidity Records; NHS NSS, National Health Service National Services Scotland; PiC, people in custody; PM, particulate matter; SHS, secondhand smoke; SPS, Scottish Prison Service; TIPs, Tobacco in Prisons.

Analysis

Mean costs and outcomes per person per month were estimated for each of the three TIPs study phases and presented separately in a balance sheet format. As previously described, data comprised two formats: monthly, and point estimates for each phase. Interrupted time series analyses were conducted for monthly data (all

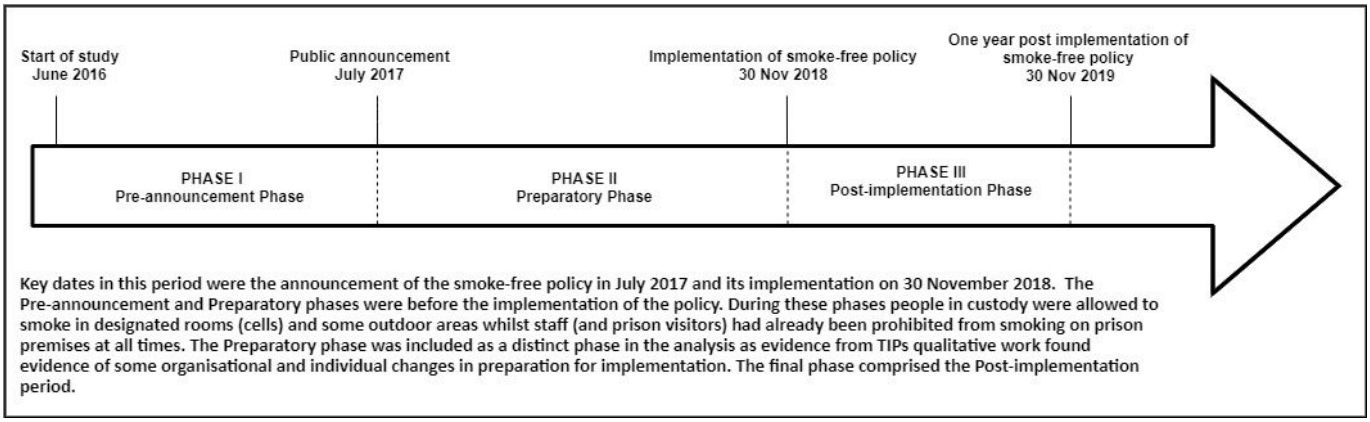

Figure 1 Tobacco in Prisons (TIPs) timeline.

costs associated with healthcare resource use (except GP/nurse visits), e-cigarette use and non-SHS non-health outcomes).[29] We included lags where autocorrelation was present and controlled for overcrowding, measured as a monthly ratio of prison population to available contracted places. Controlling for overcrowding was important as the prison population increased over the study period while the contracted available places remained mainly constant and this may have accounted for some changes in costs and outcomes. For point estimate data (GP/nurse visits, personal spend on tobacco, SHS levels and health utilities), a regression framework analysis was conducted. Ordinary least squares regression was used to estimate changes between phases. To explore uncertainty, in addition to the already described base case analysis (using preferred data and most likely assumptions), we also conducted two sensitivity analyses: the first included all dispensed medication (not restricted to nicotine dependence and smoking-related illness); the second included all PiC data from the open prison. Results are presented as an observed monthly mean for costs and outcomes and the measure of change between phases, plus 95% CI for this change.

Cost-effectiveness and cost-utility analyses

In addition to the cost-consequence analysis, cost-effectiveness (CEA) and cost-utility (CUA) analyses were also conducted from the perspective of the NHS, PiC and staff. In these analyses, mean costs and outcomes (estimated in the cost-consequence analysis) in the preannouncement phase were compared with post implementation phase (using 12-month periods), and incremental cost-effectiveness ratios were estimated, where relevant. Two sensitivity analyses were also conducted, as described in the cost-consequence analysis.

In the cost-effectiveness analysis, cost-effectiveness was expressed as incremental cost per 10 µg/m^3 reduction in $PM_{2.5}$. This increment in $PM_{2.5}$ was chosen as it is applied by the WHO when assessing mortality risk and has been used in a previous economic evaluation.[30]

Similarly, in the cost-utility analysis, cost-effectiveness was expressed as incremental cost per QALY gained. The mean health utilities estimated in the cost-consequence analysis were combined with the 12-month timeframe of the analysis to generate QALYs. Further, a scenario analysis was also conducted to estimate the long-term cost-effectiveness of the policy. A cohort model-based analysis was conducted to estimate the cost-effectiveness of the policy over a lifetime (to death).

A Markov model was developed consisting of seven health states: smoking, quit/abstinent from smoking, no smoking (never smokers) during an 'in prison' period, the same states in a 'post-prison' period and death (figure 2). PiC enter the 'post-prison' period after release, staff after stopping working for SPS.

Two cohorts (PiC and staff) enter the model and accumulate costs and QALYs annually over a lifetime (up to 70 years in the model). Costs and QALYs beyond the first year were discounted at 1.5% following current NICE recommendations for public health interventions.[13]

Full details of the model and model inputs are included in online supplemental appendix 4.

For the base case analysis, where possible, parameters were sourced from TIPs surveys and SPS reports and information. Where there were gaps in the evidence other sources were used, including literature and expert opinion. Key parameters for transitioning between states in the model include smoking status, morbidity and mortality.

To account for parameter uncertainty probabilistic sensitivity analysis was undertaken with 1000 iterations, until model convergence.[31] Results were plotted on a cost-effectiveness plane to visually represent uncertainty. Several plausible sensitivity

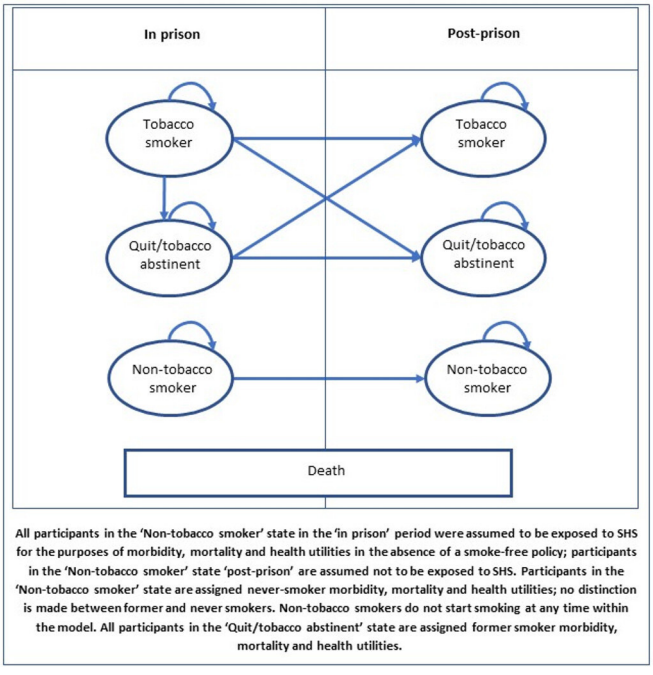

Figure 2 Markov model structure. SHS, secondhand smoke.

analyses were conducted to assess the impact of varying input parameters (parameters reported in online supplemental appendix 4). Per-person base case results were extrapolated to population level for each cohort.

Patient and public involvement

The overall design of the TIPs study, the development of survey instruments and the sampling for the qualitative data were informed by discussions with prison staff, including those working in SPS headquarters and in the prisons, representatives of prison worker unions and of Scottish Government, and NHS staff, in particular those with a remit for prison health and/or smoking cessation.[26]

RESULTS

Cost-consequence analysis

In the base case analysis most mean direct medical costs decreased (outpatient, inpatient, mental health hospital stays, accident and emergency visits, staff GP visits and smoking-related illness medication), but a small number increased (ambulance use, nicotine dependence medication and GP/nurse visits (PiC)). For personal spend, tobacco spend for PiC remained constant across the first two phases (after which tobacco was no longer available for purchase in prison canteens). PiC e-cigarette and staff tobacco spend increased.

For base case outcomes there was a marked decrease in SHS exposure (improvement in air quality), but this was not reflected in PiC health utilities which showed a decrease in self-reported health-related quality of life over all phases. This change in PiC health utilities was largely due to responses to the anxiety and depression domain of the EQ-5D-5L. Staff health utilities increased across all phases showing an improvement in health-related quality of life. For the non-health outcomes, the number of prisoner-on-staff assaults and all-cause mortality (deaths in custody) remained constant, the number of prisoner-on-prisoner assaults and PiC managed under the MORS policy showed an increase and the number of fires showed an increase in the preparatory phase and a decrease in the post implementation phase.

As expected, the impact of the policy was visible in the preparatory phase with changes in costs and outcomes, mirroring qualitative TIPs research suggesting PiC were changing some behaviours before the implementation of the policy. See online supplemental table 1 for phase means and time series figures, and online supplemental appendix 5 for changes between phases. Sensitivity analysis results are also included in online supplemental appendix 5 and showed no major impact on results.

Cost-effectiveness and cost-utility analyses

The cost-effectiveness and cost-utility use the same base case costs. These show that PiC total costs were higher overall in the absence of the policy compared with the presence of the policy (£3142 vs £3075) (online supplemental appendix 6). However, some individual cost categories for PiC were higher with the policy: GP/nurse visits, mental health hospital stays, ambulance use, medication for nicotine dependence and e-cigarettes. All staff costs were higher in the absence of the policy compared with the presence of the policy. These results show that implementing the policy is cost saving over the short term for PiC and staff.

The outcome of mean $PM_{2.5}$ (10 µg/m^3) indicated significantly better air quality with the policy than without it (0.31 compared with 3.84 $PM_{2.5}$ (10 µg/m^3)), as previously reported.

Therefore, cost-effectiveness results show that, for both PiC and staff, the policy was less costly with a better air quality outcome than the absence of the policy (a dominant strategy), although the difference in costs was small.

In the cost-utility analysis, QALYs decreased for PiC and increased for staff (reflecting the cost-consequence analysis results). The base case incremental cost per QALY for PiC was £1241, and implementing the policy is associated with reduced costs but also reduced QALYs (losing self-reported health benefits). For staff, implementing the policy was dominant (costs were lower and QALY outcomes were higher with the policy, gaining self-reported health benefits).

Results for the CEA, CUA and scenario (lifetime) analysis are reported in table 2; sensitivity analysis results are included in online supplemental appendix 6.

Scenario (lifetime) analysis

Over a lifetime, the biggest proportion of total costs for the PiC cohort was personal spend on nicotine products; for staff it was morbidity costs (online supplemental appendix 7). For both cohorts, total costs were lower with the policy compared with in the absence of the policy (table 2). This was most marked in the PiC cohort where incremental total costs were −£28 440 (95% CI −£29 433 to −£27 377) compared with −£460 (95% CI −£546 to −£367) in the staff cohort. The number of QALYs for both cohorts was higher with the policy over a lifetime: a difference of 0.971 (95% CI 0.533 to 1.376) for PiC and 0.262 (95% CI −0.033 to 0.544) for staff. These results show that the policy dominates (costs were lower and QALYs were higher) and implementing the policy would be considered cost-effective over a lifetime.

A cost-effectiveness plane, sensitivity analyses results and population-level results are included in online supplemental appendix 7. Sensitivity analyses results showed the policy remains dominant in all analyses. The population-level results indicate combined potential cost savings of more than £200 million to NHS Scotland and on personal nicotine spend over a lifetime, and around 8000 additional QALYs for the total cohort of operational staff and PiC. The share of possible cost savings that relate to NHS Scotland only is around £6 million.

DISCUSSION

Our data show that the policy is cost-effective in both the short term and long term. Results from the cost-consequence analysis, assessing changes in costs and outcomes over the three phases, showed that while most cost categories decreased, there was no consistent direction of change in outcomes after implementation. The cost-effectiveness analysis, assessing the trade-off of costs against changes in SHS levels in the presence versus absence of the policy, demonstrated cost savings and significant reductions in SHS for PiC and staff. Results from the cost-utility analysis (short term) assessing the trade-off of costs against QALYs in the presence versus absence of the policy demonstrated cost savings and QALY gains for staff, suggesting that the smoke-free policy is optimal for this population. However, the results were less clear for PiC; the cost savings were associated with a reduction in QALYs. Finally, the scenario analysis exploring the potential long-term impact of the policy over a lifetime demonstrated cost-effectiveness for both PiC and staff.

While most cost categories decreased in the short term, some increased; ambulance use, nicotine dependence medication, GP/nurse visits for PiC, PiC e-cigarettes and staff tobacco. In interpreting these results we would expect increases in nicotine

Table 2 Results for base case cost-effectiveness, cost-utility and scenario (lifetime) analysis

	Presence of smoke-free policy	Absence of smoke-free policy	Difference Mean (95% CI)	Incremental cost-effectiveness ratio
1. Cost-effectiveness analysis (incremental cost per 10 µg/m3 reduction in $PM_{2.5}$)				
People in custody				
Mean cost	£3075	£3142	−£67	Smoke-free policy dominates
Mean $PM_{2.5}$ (10 µg/m^3)	0.31	3.84	3.53	
Operational staff				
Mean cost	£197	£230	−£33	Smoke-free policy dominates
Mean $PM_{2.5}$ (10 µg/m^3)	0.31	3.84	3.53	
2. Cost-utility analysis (incremental cost per quality-adjusted life-year)				
People in custody				
Mean cost	£3075	£3142	−£67	£1241
Mean QALY	0.682	0.736	−0.054	
Operational staff				
Mean cost	£197	£230	−£33	Smoke-free policy dominates
Mean QALY	0.863	0.859	0.004	
3. Scenario (lifetime) analysis				
People in custody				
Mean cost	£22 399	£50 838	−£28 440 (95% CI 29 433 to −27 377)	Smoke-free policy dominates
Mean QALY	21.78	20.81	0.971 (95% CI 0.533 to 1.376)	
Staff				
Mean cost	£12 343	£12 803	−£460 (95% CI −546 to −367)	Smoke-free policy dominates
Mean QALY	29.82	29.55	0.262 (95% CI −0.033 to 0.544)	

dominates—less costly and more beneficial.
PM, particulate matter; QALY, quality-adjusted life-year.

dependence medication in preparation for and once the policy was implemented, and PiC e-cigarette costs once tobacco was no longer available on the canteen list. However, it is less clear why the other costs increased. A notable decrease in costs was in smoking-related illness medication, suggesting an association with decreased demand following implementation of the policy. Cost categories driving the decrease in total costs after policy implementation were inpatient stays, smoking-related illness medication and tobacco spend. Key cost categories which increased were mental health stays and e-cigarettes. In interpreting changes in outcomes, decreases in SHS levels and fires were expected with no licit access to tobacco or lighters, but the decrease in PiC health utilities is less easy to interpret. Of the five domains included in the EQ-5D-5L, anxiety/depression showed the biggest decrease for PiC. However, as we do not have identifiable EQ-5D-5L data that can be linked to individuals across phases[26] (due to the transient nature of the population), the reason behind the decrease in this domain is unclear. Several increasing outcomes (eg, assaults and drug use) included in the analysis are known to be caused by multiple, fluctuating factors, making interpretation of the impact of the policy challenging.[32 33]

Further interpretation of the lifetime sensitivity analyses results demonstrated that the extent to which people resume smoking on release from prison and the cost of tobacco outside prison, were the key drivers of the model results. The population-level extrapolation estimated lifetime cost savings of around £200 million for healthcare and personal nicotine spend among PiC and staff. While we were unable to include full intervention costs, this figure illustrates a substantial cost saving, even if additional intervention costs were incorporated.

This is the first economic evaluation to assess the impacts of implementing a smoke-free policy across an entire national prison service. Research in the prison setting is challenging and often relies on multiple sources of data; we were able to conduct this economic evaluation by incorporating a range of costs and outcome measures. This enabled a comprehensive assessment of the impacts on multiple sectors with an understanding of how and to what extent outcomes changed over time. Furthermore, data from SPS added validity to our findings. While the cost-utility framework is helpful, it is often not sufficient in evaluating public health interventions where not all relevant outcomes are captured by the QALY. By including a cost-consequence analysis we were able to incorporate additional outcomes to show wider impacts of the policy.[34]

Despite being able to amass data on a wide range of pertinent costs and outcomes and to assess benefits and unintended adverse consequences, uncertainty remains relating to routine data identification. As there are no validated methods of identifying healthcare use data for PiC from NHS NSS sources and due to time and other constraints, operationalising individual-level linkage was not possible in this large and transient population. Pragmatic methods of identification were used with input from colleagues from NHS NSS[19] and this may have affected the precision of the result estimates. Furthermore, data were obtained from several sources in various formats, requiring different methods of analysis, adding to the complexity of the analysis.

Information on the costs of implementing the policy, to the SPS and more widely, was limited. We included the costs of e-cigarette starter kits provided by SPS to eligible PiC in the lifetime analysis, but this alone is likely to underestimate the costs associated with staff training, policy communication, contingency preparation and increased provision of smoking cessation services. Smoking cessation costs were not included because of the differing mechanisms of provision across prisons, although nicotine dependence medication was included and showed an increase in the study period. Costs were not included for monitoring SHS levels inside

prisons (which was undertaken as part of the TIPs research[26]) when assessing the need for the policy, as this was considered to be a research cost and not an implementation cost. This is an important consideration for other jurisdictions introducing smoke-free prison policies, as the preannouncement phase SHS exposure measurements partially informed the need for and timing of Scotland's smoke-free prison policy.[12] However, costs for equipment, training and adequate SHS measurement are relatively small. We were also unable to include costs such as insurance, air conditioning, building maintenance and restoring fire damage, all of which could arguably have been expected to change as a result of the policy implementation. It is important to note that implementing the policy was achieved reportedly with no major unrest or significant damage to property. It was not possible to include these outcomes in our analyses, although we did include assaults and fires, neither of which saw significant increases. Had major unrest or property damage occurred, the costs to the SPS and beyond could have been significant, as well as causing adverse consequences for PiC and staff.

While evidence to date suggests that e-cigarette use is less harmful than tobacco use,[35] it is unlikely to prove entirely risk free. Because there is scarce evidence on the effects of long-term e-cigarette use, we did not include any health benefits or harms of e-cigarette use in the lifetime model. Our qualitative research suggests that e-cigarette use behaviours among PiC may differ in some ways to the general population so any benefits or harms may be different in this population. For example, some may be susceptible to heavy use, as a consequence of high nicotine dependence and/or situational factors such as product choice and availability and prison regimes.[23 24]

As this is the first economic evaluation of a smoke-free prison policy, we cannot make direct comparisons to existing research. However, we can compare our model results with what is considered a minimally important QALY gain; 0.074 (95% CI −0.011 to 0.140).[36] Our individual QALY gains are 0.971 and 0.262 for PiC and staff, respectively, considerably larger than the upper 95% CI of 0.140, so we can assume the model results would be considered important by decision makers. Research on quality of life for hospital employees, comparing an inside-only smoking ban to an inside-and-outside ban, found a lifetime benefit of 0.355 QALYs.[37] A study evaluating the cost-effectiveness of a complex intervention to reduce SHS exposure in children estimated a cost of £131 per 10 µg/m^3 reduction in $PM_{2.5}$, compared with absence of policy being dominated in our research.[30]

There is scarce evidence available on the extent to which people resume smoking on release from prison[38]; this a key driver of the long-term results of a smoke-free prison policy evaluation. Future research should monitor rates of resumption on release and consider ways of supporting continued tobacco abstinence, with or without e-cigarettes. Furthermore, research is needed into potential spillover effects on household members when PiC are released. Finally, more evidence is needed on any long-term benefits and harms of e-cigarettes, particularly in this population, to inform decisions about e-cigarette provision by other jurisdictions considering implementing a smoke-free policy in future.

CONCLUSION

This study assessed the cost-effectiveness of a smoke-free prison policy compared with no smoke-free policy. The short-term analysis found cost savings for PiC and staff, with no consistent direction of change in outcomes. The lifetime analysis found that implementing the policy was cost-effective for both PiC and staff. In terms of implications, introducing the policy was cost-effective from the traditional cost-utility analysis criteria and when assessing broader outcomes; it was worthwhile adopting the policy. Jurisdictions planning to implement a smoke-free prison policy should consider the provision of e-cigarettes, nicotine dependence medication and smoking cessation support, in light of their national policies, alongside the costs of monitoring SHS levels. The policy was implemented with no major negative impacts. Any future economic evaluations of such policies should consider a broad range of outcomes and ensure the impact on PiC and staff is measured.

What this paper adds

What is already known on this topic

⇒ In countries, where still permitted, smoking prevalence in prisons is much higher than in the general population, affecting the health of everyone in custody and those working in the prison environment, thus contributing to inequalities in health.

⇒ There is no evidence internationally on the cost-effectiveness of introducing smoke-free policies in a prison setting.

What this study adds

⇒ Implementing a smoke-free prison policy is cost-effective over the short term and long term for people in custody and operational staff.

How this study might affect research, practice or policy

⇒ As the first economic evaluation of a smoke-free prison policy, this research provides a foundation for methods and evidence in this field internationally.

⇒ Jurisdictions contemplating on implementing a smoke-free prison policy should consider the provision of e-cigarettes, nicotine dependence medication and smoking cessation support.

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Contributors NM, OW and KAB conceived and designed the economic evaluation. NM carried out the analysis and interpretation and drafted the manuscript. OW and KAB supervised NM, interpreted the analysis and commented in detail on drafts of the manuscript. AB and KH liaised with SPS regarding the data used in the analysis, contributed to the interpretation of the various stages of analysis and commented in detail on drafts of the manuscript. EJT liaised with NHS NSS for healthcare and pharmacy data and gave interpretation of those data. CB analysed the canteen data included in the economic evaluation, with input from AB and KH. PC, AHL, ED, LG, JP and KH interpreted the analysis results. TB provided prescription data and interpretation of those data. SS provided SHS data and interpretation of those data. HS provided TIPs survey data and interpretation of those data. LG liaised with NHS NSS and gave interpretation of these data and previous research into people in custody. KH was PI for the TIPs study and gave advice on the design of the economic evaluation and interpretation of data. KAB, PC, AHL, ED and SS were coinvestigators on the TIPs study. All coauthors edited and revised the manuscript and approved the final version. NM is the guarantor of the study.

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Supplementary Appendix

Appendix 1 Resources included in short-term base-case analyses

Supplementary Table 1 Data (PiC) available separately for closed and open prisons in base-case analysis

Resource/Outcome	Data available separately for closed and open prisons – therefore open prison excluded from analysis
GP/nurse - PiC	✓
Outpatient/inpatient/mental health stay	
Ambulance	✓
A&E	
Medication	✓
Staff tobacco	
Pic tobacco and NVP	✓
QALYs - PiC	✓
Violence	✓
Deaths	
Fires	✓
MoRs	✓

Appendix 2 Short-term analyses: sources, format and unit costs for resources use data

Identifying resource use

Health service use

GP and nurse visits (PiC and staff)

Data were extracted from TIPs staff and PiC surveys in all phases for the number of visits to GP/nurse reported in the previous 3 months, from which monthly resource use was calculated.

Outpatient attendances, inpatient and mental health length of stay, and accident and emergency attendances (PiC only)

These data were provided by NHS National Services Scotland (NHS NSS). The conventional method of identifying individual patient resource use in this data is the Community Health Index (CHI) number, a unique identifier given to patients accessing Scottish health care. Due to the complexity and practicalities of linking individual records from the above datasets, other identification methods for PiC health service use were applied. These are described for each dataset below. All data extracted covered the study period of 1 June 2016 to 30 November 2019 and were received in an aggregate monthly format.

Outpatient attendances (SMR00)

Two variables available in the outpatient dataset were used to identify PiC attendances: 1) GP practice code (prison GP practices are all allocated the same code), and 2) 'referral source code', for these purposes the referral category 'prison/penal establishment' was used. Data identified by at least one of these variables were included in the analysis.

Inpatient and mental health length of stay (SMR01 and SMR04)

Two variables, GP practice code and 'admission/transfer from' were used to identify PiC resource use in the inpatient and mental health datasets for length of stay, the admission category 'legal establishment including prison' was used. Data identified by at least one of these variables were included in the analysis.

Accident and emergency attendances (A&E2)

Accident and emergency attendances were identified using the 'postcode of residence' field, this was feasible as prisons have unique postcodes.

Ambulance incidents (PiC only)

The aggregate number of ambulance incidents was provided by SPS for each prison, from 1 June 2016 to 30 November 2019.

Medication (PiC only)

Medication dispensed to PiC from 1 June 2016 to 30 November 2019 was provided by National Procurement, NHS NSS. Data was included for named patients and stock supply, extracted as an aggregate monthly cost. The base-case analysis includes two categories of medication; 1) indicators of nicotine dependence and 2) indicators of smoking-related illnesses or associated symptoms, the rationale for this is these are the medications most likely to change following the implementation of a smoke-free policy. A sensitivity analysis (SA1) was conducted including all medication.

Nicotine products

PiC tobacco and NPV

PiC spending on tobacco and NPV products was extracted from canteen data provided by SPS for a TIPs related CRUK-funded study. Each prison has a canteen (shop) from which PiC can purchase items on the canteen list; tobacco products were taken off the canteen list in November 2018 and NPV were available on the canteen list from September 2018. Data was available from 29 July 2018 for both tobacco and NPV (four months prior to implementation of the smoke-free policy), to November 2018 for tobacco and November 2019 (end of study period) for NPV. Analysis showed that spend on tobacco products was constant in the months leading to the policy implementation and we assumed that tobacco spend earlier than 29 July 2018 was consistent with the spend from July 2018 onwards, an average monthly spend was applied to the earlier months of the study period based on mean spend for August to October 2018 when full months' data was available. Data was not available for Scotland's two privately run prisons.

Staff tobacco

The weekly number of cigarettes smoked was extracted from the TIPS staff surveys from each phase combining the reported number of cigarettes smoked on workdays and days off. The weekly consumption of cigarettes was assumed to be constant across each phase and a monthly usage was estimated based on this assumption, for each phase.

Supplementary Table 2 Short-term analyses: resource use sources and formats summary

	Source	Time period data covers	Data point frequency	Data format
Resource use				
Healthcare				
People in custody				
GP/nurse visits	Survey - number of visits in previous 3 months	All 3 phases	3 timepoints; Nov 2016/April 2017, June/July 2018 & May/June 2019	From individuals, (mean, sd n)
Outpatients	NHS NSS (ISD SMR00)	Jun 2016 -Nov 2019	Monthly	Aggregate data for all PiC, (total monthly count)
Inpatient stays	NHS NSS (ISD SMR01)	June 2016 to Nov 2019	Monthly	Aggregate data for all PiC, (total monthly count – admissions and los)
Mental health stays	NHS NSS (ISD SMR04)	June 2016 to Nov 2019	Monthly	Aggregate data for all PiC, (total monthly count – admissions and los)
A&E	NHS NSS (ISD Unscheduled Care A&E2)	June 2016 to Nov 2019	Monthly	Aggregate data for all PiC, (total monthly count)
Ambulance	Scottish Prison Service	June 2016 to Nov 2019	Monthly	Aggregate data for all PiC, (total monthly count)
Medication	National Procurement, NHS NSS	June 2016 to Nov 2019	Weekly	Aggregate data for all PiC, (total monthly count)
Staff				
GP visits	Staff survey - number of visits in previous 3 months	All 3 phases	3 timepoints; Nov/Dec 2016, May/July 2018 & April/July 2019	From individuals, (mean, sd n)
Nicotine products				
People in custody				
Cigarettes	SPS canteen data	3 months prior to ban	Monthly	Aggregate data for all PiC (total

				resource use and spend)
Nicotine vaping products	SPS canteen data	3 months prior to ban, onwards	Monthly	Aggregate data for all PiC (total resource use and spend)
Staff				
Cigarettes	Survey – phase 1, 2 & 3, how many cigarettes per day	All 3 phases	3 timepoints; Nov/Dec 2016, May/July 2018 & April/July 2019	From individuals, (mean, sd n)

Supplementary Table 3 Short-term analyses: unit costs

Resource use	Unit cost	Source
Health		
People in custody		
GP/nurse visits	£20.30	PSSRU 2017/18 GP and nurse, length of consultation from PSSRU 2015
Outpatients	£176.00	ISD cost book 2017/18 R044X, consultant led new patient, cost per attendance
Inpatient stays		
Mean across all specialities	£1,190.00	ISD cost book 2017/18 R040, cost per bed day
Accident & Emergency	£1,492.34	
Cardiac Surgery	£2,042.72	
Cardiology	£720.16	
Clinical Oncology	£1,009.80	
Dermatology	£514.63	
Ear, Nose & Throat	£1,290.04	
Gastroenterology	£554.54	
General Medicine	£482.35	
General Surgery (exc Vascular Surgery)	£865.83	
Gynaecology	£1,543.31	
Haematology	£1,097.21	
Intensive Care Unit	£2,217.48	
Medical Oncology	£1,286.00	
Neurology	£1,128.05	
Neurosurgery	£1,439.17	
Ophthalmology	£1,596.58	
Plastic Surgery & Burns	£1,705.61	
Respiratory Medicine	£510.46	
Thoracic Surgery	£1,359.73	
Urology	£938.50	

Vascular Surgery	£652.04	
Mental health stays		
General Psychiatry	£3,645	ISD cost book R040LS, cost per inpatient week
Geriatric Psychiatry	£2,669	
Learning Disabilities	£4,833	
Adolescent Psychiatry	£6,158	
Child and Adolescent Psychiatry	£6,158	
A&E	£137	ISD cost book 2017/18, R044 cost per attendance
Ambulance	£310	ISD cost book R910 2017/18 cost per incident (accident & emergency, All Scotland)
Medication	Various	Included in National Procurement dataset
Staff		
GP visits (staff	£31.30	PSSRU 2017/18
Personal		
People in custody		
Cigarettes	Various	Included in SPS canteen data
E-cigs/vapes	Various	Included in SPS canteen data
Staff		
Cigarettes	£10.23 for 20 king size	ONS

Appendix 3 Short-term analyses: sources and format for outcome data

Supplementary Table *4* Short-term analyses: outcomes sources and formats

Outcomes				
	Source	**Time period data covers**	**Data point frequency**	**Data format**
Utilities	TIPS staff and PiC surveys	All 3 phases	3 timepoints, one in each phase	From individuals, (mean, sd n)
Concentration of second-hand smoke levels ($PM_{2.5}$)	TIPs study	All 3 phases	3 timepoints, one in each phase	Per prison (1, 2)
Prisoner on staff assaults	SPS	November 2017 to November 2019	Monthly	Aggregate data for all PiC (total count)
'Prisoner-on-prisoner' assaults	SPS	November 2017 to November 2019	Monthly	Aggregate data for all PiC (total count)
All-cause mortality (deaths in	SPS	June 2016 to November	Monthly	Aggregate data for all PiC (total count)

custody) amongst PiC		2019		
Fires	SPS	June 2016 to November 2019	Monthly	Aggregate data for all PiC (total count)
The Management of an Offender at Risk due to any Substance Policy (MORS)	SPS	June 2016 to November 2019	Monthly	Aggregate data for all PiC (total count)

PiC – people in custody

Appendix 4 Scenario (lifetime) analysis : description and model input parameters

Model structure

The model is split into two time periods; 'in prison' and 'post-prison', each with four states ('Tobacco smoker', 'Quit/tobacco abstinent', 'Non-tobacco smoker' and 'Death'). PiC enter the model at the start of their first custodial sentence and staff enter the model when they begin employment with SPS. PiC enter the post-prison period on release from prison and staff on leaving employment with SPS.

Within each time period participants can either remain in their state, transition from 'Tobacco smoker' to 'Quit/tobacco abstinent', or transition from any live state to 'Death'. When transitioning from the 'in prison' to the 'post-prison' period, model participants can remain in the state they were previously in; this is always the case with participants in the 'Non-tobacco smoker' state. 'Tobacco smokers' can also transition to 'Quit/tobacco abstinent', and 'Quit/tobacco abstinent' can resume smoking. Following the implementation of smoke-free prison policy, all PiC entering the model as 'tobacco smokers' will immediately transition to 'Quit/tobacco abstinent'.

The following model assumptions were applied:

- All participants in the 'Non-tobacco smoker' state in the 'in prison' period are assumed to be exposed to SHS for the purposes of morbidity, mortality and health utilities in the pre-policy comparator.
- Participants in the 'Non-tobacco smoker' state 'post-prison' are assumed not to be exposed to SHS.
- Participants in the 'Non-tobacco smoker' state are assigned never-smoker morbidity, mortality and health utilities; there is no distinction between former smokers and never smokers.
- All participants in the 'Quit/tobacco abstinent' state are assigned former smoker morbidity, mortality and health utilities, in line with existing economic smoking cessation models (3).
- Non-tobacco smokers do not start smoking at any time during the model; this assumption is mitigated by applying PiC smoking prevalence (4).

Input parameters

For the base-case analysis, where possible, parameters were sourced from TIPs surveys and SPS reports and information. Where there were gaps in the evidence other sources were used, including literature (referenced below) and expert opinion.

Model input parameters are reported in Supplementary Table 5 and described below.

Model transitions

Smoking status

Smoking prevalence for PiC and staff were sourced from the Phase-1 TIPs survey (5) and used to populate the initial states in the 'in prison' period in both comparators. PiC entered the model as either 'Tobacco smokers' or 'Non-tobacco smokers' pre-policy, and 'Quit/tobacco abstinent' or 'Non-tobacco smokers' post-policy. Staff were either 'Tobacco smokers' or 'Non-tobacco smokers' in both comparators.

To account for PiC and staff who quit smoking in the model, a background quit rate was applied to the 'Tobacco smoker' state, in line with existing smoking cessation models (6).

For PiC entering the 'post-prison' period in the post-policy comparator assumptions about smoking resumption were sourced from the PiC TIPs survey on perception of smoking status post-release from prison.

Morbidity

Smoking related morbidity was applied to all model participants: diseases comprised coronary heart disease (CHD), chronic obstructive pulmonary disease (COPD), lung cancer and stroke (7). Morbidity transitions were specific to smoking status, gender and age and used three inputs; sex and age specific morbidity prevalence irrespective of smoking behaviour; the prevalence of sex and age specific smoking behaviour; and the sex and age specific morbidity relative risk for current and former smokers, with never smokers assigned a relative risk of 1. The prevalence of each smoking related disease was assumed to be independent of others given the lack of evidence to support alternative assumptions.

There is evidence of a causal link between exposure to SHS and CHD and lung cancer in never smokers (8), so non-tobacco smoking model participants pre-policy (in prison) are assigned CHD and lung cancer morbidity adjusted for exposure to SHS.

Mortality

Sex, age and smoking status specific mortality rates were applied based on the general Scottish population data and calculated as follows. Scottish sex and age specific mortality rates for 2018 (9) were modified for the increased risk of mortality for smokers and former smokers reported by Doll et al (10), and sex and age specific smoking prevalence for the Scottish general population was applied to this calculation (11).

There is evidence to suggest that PiC have a lower mortality rate while in prison and a higher mortality rate when released from prison compared to the general population (12-14). To adjust for these different mortality rates, sex specific standardised mortality ratios were applied to the mortality rates for the general Scottish population. The general Scottish population mortality rates were applied to staff with no adjustment.

It is estimated that exposure to SHS accounts for 1% of total mortality globally (8, 15): to replicate this increased mortality for non-tobacco smoking model participants, the mortality of those not exposed to SHS was reduced by 1%. These model participants comprised non-tobacco smokers in the 'post-prison' period for both comparators and non-tobacco smokers 'in prison' post-policy.

Costs

Resource use categories comprised the intervention, annual healthcare for morbidities, and spend on nicotine products by PiC and staff, valued at 2017/18 prices, uplifted where needed (16). Sources include a freedom of information request (FOI), literature, SPS canteen data analysed in a parallel CRUK-funded study and the TIPs surveys.

Intervention costs

Intervention costs comprise the cost to the SPS of providing e-cigarettes starter packs to PiC (17). This cost was applied to all PiC post-policy regardless of smoking status in the model as a conservative approach.

Healthcare costs

The annual costs of CHD, COPD, lung cancer and stroke were applied to model participants with each morbidity (3).

Tobacco and nicotine vaping products

The mean weekly spend on tobacco by PiC was extracted from SPS canteen data and was assumed to be consistent throughout the year. An annual cost was estimated based on this and applied to PiC in the 'Tobacco smoker' state in the 'in prison' period pre-policy. Post-policy no tobacco costs for PiC were applied in the 'in prison' period. In the 'post-prison' period for both comparators the reported daily number of cigarettes smoked by PiC was extracted from the Phase-1 TIPs survey. The usage was assumed to be consistent across the year to allow estimation of an annual usage, and a cost per cigarette applied to this total. Weekly e-cigarette costs for the 'in prison' period post-policy were extracted from SPS canteen data. E-cigarette costs were assumed to be consistent throughout the year and an annual cost was calculated. This annual cost was applied to all former smokers in the 'in prison' period post-policy.

The number of reported daily cigarettes smoked by operational staff was extracted from the TIPs survey for Phases I and III, to represent the without and with a smoke-free policy comparators. An annual usage was calculated assuming that this reported number of cigarettes smoked was consistent throughout the Phases and year and a cost per cigarette applied to the annual usage.

Outcomes

The model outcome was the QALY, a combination of quality and length of life. A quality of life utility was estimated using responses to the EQ-5D-5L questionnaires in the TIPs surveys, dependent on smoking status, for PiC and staff, for Phase-1 and Phase-3. Non-smoker health utilities reported in Phase-1 of the TIPs surveys were assumed to include a decrement related to SHS exposure. Model participants allocated a smoking related morbidity were assigned a disease specific health utility sourced from literature, as is best practice (18).

Other model inputs

The mean age entering the model was 27 years for PiC (12) and 28 years for operational staff (data provided by SPS and based on the position at 31st March 2020).

The mean length of time in the 'in-prison' period was three years for PiC (calculated using the mean length of sentence and mean number of incarcerations in Scotland (12, 19, 20)), and 16 years for staff (provided by SPS and based on the position at 31st March 2020).

Analysis

The model was developed using Microsoft Excel for Office 365. Results from the sex specific cohorts were combined applying ratios of male to female PiC (95:5) and staff (73:27) to estimate a per person cost and QALY. Base-case results presented for PiC and staff include a breakdown of total mean costs, total and incremental mean costs and QALYs and 95% confidence intervals around incremental results.

Uncertainty

Uncertainty in input parameters was characterised with a probabilistic sensitivity analysis (PSA) using best practice techniques (21), with results used to estimate the 95% confidence interval around the costs, QALYs and the ICER. The following distributions were fitted for the PSA: for relative risk, lognormal; for costs, gamma and for health utilities, beta. 1,000 iterations were run based on model convergence guidance (22) and results were plotted on a cost-effectiveness plane to visually represent uncertainty.

Several plausible sensitivity analyses were conducted to assess the impact of varying input parameters on the base-case cost-effectiveness results, altering the length in prison, resumption of tobacco smoking on release, varying PiC spend on nicotine products, applying health utilities from the literature and replacing TIPs input parameters with parameters from the literature as far as possible. Input parameters for the sensitivity analysis are included in Supplementary Table 6.

Population-based analysis

For the population-based analysis the mean number of PiC was 7,500 (based on mean daily population SPS annual report and accounts 2017-18 (23)), and the number of staff was 3,244 (provided by SPS and based on the position at 31st March 2020). In this analysis the total cost of vaping kits to SPS was applied for intervention costs(24).

Supplementary Table 5 Scenario (lifetime) analysis: lifetime model base-case input parameters

Parameter	Mean	PSA – distribution (alpha, beta)	Source
Model transitions			
Smoking prevalence:			
PiC	0.74	N/A	TIPs PiC survey
Staff	0.09	N/A	TIPs staff survey
Background quit rate	0.02	N/A	NICE(12)
Resumption on release (PiC)	0.42	N/A	TIPs PiC survey
Smoking related morbidity	Various depending on disease, age and sex	Lognormal (various depending on disease, age and sex)	Jones et al.(3)
Morbidity SHS exposure:			

CHD	1.27 (1.19-1.36)	Lognormal (lnmean 0.239, lnse 0.034)	Öberg et al.(25)
Lung cancer	1.21 (1.13–1.30)	Lognormal (lnmean 0.191, lnse 0.036)	
Mortality:			
PiC mortality SMR:			Graham et al.(12)
In prison – female PiC	1.9 95% CI 0.9, 3.5	Lognormal (lnmean 0.642, lnse 0.346)	
In prison – male PiC	0.6 95% CI 0.5, 0.7	Lognormal (lnmean -0.511, lnse 0.086)	
Out of prison – female PiC	5.9 95% CI 5.4, 6.5	Lognormal (lnmean 1.775, lnse 0.0.047)	
Out of prison -male PIC	2.5 95% CI 2.4, 2.6	Lognormal (lnmean 0.916, lnse 0.020)	
Staff mortality	Various depending on age, sex and smoking status	Lognormal (various depending on disease, age and sex)	National Records of Scotland(26), Doll et al.(27) & Scottish Health Survey 2017(28)
Costs:			
Intervention (per person)	£14 per PiC	N/A	BBC FOI(24)
Intervention (population level)	£150,000 for whole population	N/A	BBC FOI(24)
Morbidity healthcare:			
CHD	£1,958 (SE £195)	Gamma (99.95, 19.59)	Jones et al(3)
COPD	£899 (SE £90)	Gamma (100.07, 8.98)	
Lung cancer	£10,178 (SE £1,018)	Gamma (100.00, 101.78)	
Stroke	£4,630 (SE £32)	Gamma (21578.7, 0.215)	
Nicotine personal spend:			
Mean price of 20 king size filter cigarettes (2018)	£10.23	N/A	ONS(29)
Staff tobacco (absence of smoke-free policy)	£2,290 (SE 20.64)	Gamma (12312.9, 0.186)	ONS(29) applied to TIPs staff questionnaire (phase 1)
Staff tobacco (presence of smoke-free policy)	£2,054 (SE 23.65)	Gamma (7538.7, 0.272)	ONS(29) applied to TIPs staff questionnaire (phase 3)
PiC Tobacco (absence of smoke-free policy) 'in prison'	£412 (SE 0.665)	Gamma (384014.3, 0.001)	Canteen data
PiC Tobacco (both comparators) 'post-prison'	£3,590 (SE 29.80)	Gamma (14511.1, 0.247)	ONS(29) applied to TIPs PiC questionnaire (Phase 1)
PiC NVP (presence of smoke-free policy)	£306 (SE 0.399)	Gamma (586379.6, 0.0005)	Canteen data
Outcomes - utilities:			
Staff			
Never smoker (absence of smoke-free policy)	0.854	Beta (3309.37, 565.77)	TIPs staff questionnaire Phase 1

Former smoker (absence of smoke-free policy)	0.863	Beta (3326.49, 528.08)	TIPs staff questionnaire Phase 1
Current smoker (absence of smoke-free policy)	0.87	Beta (536.99, 80.24)	TIPs staff questionnaire Phase 1
Never smoker (presence of smoke-free policy)	0.874	Beta (1082.84, 156.11)	TIPs staff questionnaire Phase 3
Former smoker (presence of smoke-free policy)	0.848	Beta (1244.09, 223.0)	TIPs staff questionnaire Phase 3
Current smoker (presence of smoke-free policy)	0.882	Beta (283.62, 37.95)	TIPs staff questionnaire Phase 3
PiC			
Never smoker (absence of smoke-free policy)	0.777	Beta (795.86, 228.41)	TIPs PiC questionnaire Phase 1
Former smoker (absence of smoke-free policy)	0.778	Beta (932.37, 266.05)	TIPs PiC questionnaire Phase 1
Current smoker (absence of smoke-free policy)	0.722	Beta (4024.75, 1549.70)	TIPs PiC questionnaire Phase 1
Never smoker (presence of smoke-free policy)	0.779	Beta (463.28, 131.43)	TIPs PiC questionnaire Phase 3
Former smoker (presence of smoke-free policy)	0.775	Beta (1116.09, 324.03)	TIPs PiC questionnaire Phase 2
Current smoker (presence of smoke-free policy)	0.708	Beta (2986.42, 1231.69)	TIPs PiC questionnaire Phase 2

CHD – coronary heart disease; CI – confidence interval; COPD – chronic obstructive pulmonary disease; lnmean – lognormal of mean; lnse – lognormal of standard error; PiC – person/people in custody; PSA – probabilistic sensitivity analysis; SHS – second-hand smoke; SMR – standardised mortality ratio

Supplementary Table 6 Scenario (lifetime) analysis: sensitivity analyses input parameters

Scenario	**Base-case assumptions**	**Input parameters**	**Source**
1) PiC resumption of smoking on release	42% resumption based on TIPs PiC survey results	0.95	Plausible level of resumption (30)
2) PiC time in prison – 1 year	3 years based on mean length of sentence and	1 year	Plausible alternative to demonstrate effect of length of sentence on results
3) PiC time in prison – 5 year	3 years based on mean length of sentence and	5 years	
4) PiC 'In prison' tobacco and e-cigarette spend: TIPs survey	PiC 'In prison' tobacco and e-cigarette spend based on canteen data	£693	TIPs PiC survey
5) PiC 'Post prison' tobacco spend: canteen 'in prison' data	Based on TIPs PiC reported number of cigarettes smoked plus ONS unit cost of cigarette	£412	Canteen data

6) Published utilities (PiC and staff)	Utilities reported in TIPs PiC and staff surveys	Never smoker exposed to SHS (1.1% decrement)	0.869	Maheswaran H., Petrou S., Rees K., Stranges S. Estimating EQ-5D utility values for major health behavioural risk factors in England. J Epidemiol Community Health 2013; 67: 172–80
		Never smoker – no SHS	0.879	
		Former smoker	0.818	
		Moderate smoker	0.828	
		Heavy smoker	0.767	
7) Replacing TIPs data with published data as far as possible				
PiC smoking prevalence	74% TIPs PiC survey	68%		SPS 16th Prisoner survey
Staff smoking prevalence	9% TIPs staff survey	20% male and 16% female		Scottish Health Survey
PiC resumption of smoking on release	42% TIPs PiC survey	100%		Most conservative scenario – all PiC resume tobacco smoking on release
Utilities	TIPs PiC survey	Never smoker exposed to SHS (1.1% decrement)	0.869	Maheswaran H., Petrou S., Rees K., Stranges S. Estimating EQ-5D utility values for major health behavioural risk factors in England. J Epidemiol Community Health 2013; 67: 172–80
		Never smoker – no SHS	0.879	
		Former smoker	0.818	
		Moderate smoker	0.828	
		Heavy smoker	0.767	

Appendix 5 Short-term cost-consequence analysis results

Supplementary Table 7 Cost-consequence analysis results: changes between phases (base-case analysis)

	Change Phase 1 v Phase 2		Change Phase 2 v Phase 3	
	Step change	Slope change	Step change	Slope change
	Co-efficient (95% CI)	Co-efficient (95% CI)	Co-efficient (95% CI)	Co-efficient (95% CI)
Base-case - Costs				
Outpatient ǂ	-0.731 (-1.64 to 0.173)	-0.003 (-0.093 to 0.086)	-0.609 (-0.875 to -0.343)	-0.004 (-0.056 to 0.048)
Inpatient ǂ	-8.56 (-14.9 to -2.23)	0.110 (-0.498 to 0.719)	0.443 (-6.93 to 7.81)	-1.13 (-1.85 to -0.409)
Mental health hospital stays ǂ	-193 (-729 to 342)	-62.7 (-140 to 15.0)	-266 (-497 to -35.3)	4.96 (-25.4 to 35.3)
Accident & emergency visits ǂ	0.045 (-0.146 to 0.236)	-0.037 (-0.065 to -0.010)	-0.061 (-0.206 to 0.083)	-0.047 (-0.080 to -0.013)
Ambulance ǂ	0.330 (-0.081 to 0.740)	-0.061 (-0.108 to -0.014)	0.340 (-0.084 to 0.764)	0.025 (-0.045 to 0.094)
Medication (nicotine dependence) ǂ	-0.194 (-0.592	0.049 (-0.015 to	-0.578 (-1.73 to	-0.032 (-0.189

	to 0.205)	0.113)	0.574)	to 0.124)
Medication (smoking related illness) ǂ	-3.59 (-10.4 to 3.25)	-0.337 (-1.01 to 0.339)	-0.233 (-0.723 to 0.257)	0.008 (-0.029 to 0.044)
E-cigarettes ǂ	N/A	N/A	11.3 (9.33 to 13.3)	-0.741 (-1.33 to -0.155)
	Change Phase 1 v Phase 2		**Change Phase 2 v Phase 3**	
Person in custody GP/nurse visits *	0.677 (-0.399 to 1.75)		0.447 (-1.32 to 2.22)	
Staff GP visits *	-0.364 (-1.07 to 0.345)		-0.675 (-1.45 to 0.099)	
Person in custody tobacco *	N/A		N/A	
Staff tobacco *	0.049 (-5.34 to 5.44)		-0.979 (-7.19 to 5.23)	
Base-case - Outcomes				
	Step change	**Slope change**	**Step change**	**Slope change**
	Co-efficient (95% CI)	**Co-efficient (95% CI)**	**Co-efficient (95% CI)**	**Co-efficient (95% CI)**
Prisoner-on-staff assaults	N/A	N/A	-0.001 (-0.003 to 0.001)	-0.0001 (-0.0004 to 0.0002)
Prisoner-on-prisoner assaults	N/A	N/A	0.004 (-0.001 to 0.009)	-0.0008 (-0.002 to 0.0001)
All cause mortality (deaths in custody)	-0.00003 (-0.0003 to 0.0003)	0.00002 (-0.00002 to 0.00005)	0.0002 (-0.0001 to 0.0005)	0.000002 (-0.00005 to 0.00004)
Fires	0.0005 (0.00002 to 0.001)	0.00004 (-0.00004 to 0.0001)	-0.0009 (-0.002 to -0.00002)	-0.00005 (-0.0001 to 0.00005)
MORS	0.009 (0.0006 to 0.017)	0.00005 (-0.0008 to 0.0009)	0.003 (-0.007 to 0.013)	-0.0002 (-0.001 to 0.001)
	Change Phase 1 v Phase 2		**Change Phase 2 v Phase 3**	
Levels of second-hand smoke (µg/m³) Mean $PM_{2.5}$ (SD) *	-27.3 (-43.8 to -10.8)		-8.01 (-10.5 to -5.6)	
Utilities (person in custody) Mean (SD) *	-0.010 (-0.026 to 0.005)		-0.043 (-0.062 to -0.025)	
Utilities (staff) Mean (SD) *	0.003 (-0.008 to 0.014)		0.001 (-0.014 to 0.015)	

ǂ time series analysis, * regression framework, MORS - The Management of an Offender at Risk due to any Substance

Supplementary Table 8 Cost-consequence results: changes between phases (sensitivity analyses)

	Change Phase 1 v Phase 2		**Change Phase 2 v Phase 3**	
	Step change	**Slope change**	**Step change**	**Slope change**
	Co-efficient (95% CI)	**Co-efficient (95% CI)**	**Co-efficient (95% CI)**	**Co-efficient (95% CI)**
Sensitivity analysis 1 Costs - all medication				
Medication (all) ǂ	14.2 (-12.7 to 41.0)	-1.10 (-3.58 to 1.37)	2.58 (-17.0 to 22.1)	0.280 (-2.98 to 3.54)
Sensitivity analysis 2 Costs - including open prison				
Ambulance ǂ	0.269 (-0.177	-0.059 (-0.111 to -	0.325 (-0.071	0.020 (-0.046 to

	to 0.716)	0.007)	to 0.720)	0.085)
Medication (nicotine dependence) ǂ	-0.209 (-0.651 to 0.233)	0.037 (-0.030 to 0.104)	-0.435 (-1.62 to 0.747)	-0.031 (-0.198 to 0.136)
Medication (smoking related illness) ǂ	-3.54 (-10.3 to 3.25)	-0.340 (-1.00 to 0.321)	-0.225 (-0.707 to 0.256)	0.007 (-0.038 to 0.052)
Medication (all) ǂ	12.9 (-12.3 to 38.1)	-1.35 (-3.75 to 1.06)	1.30 (-16.9 to 19.6)	0.072 (-3.03 to 3.17)
E-cigarettes ǂ	N/A	N/A	11.1 (9.18 to 13.0)	-0.772 (-1.32 to -0.224)
	Change Phase 1 v Phase 2		**Change Phase 2 v Phase 3**	
GP/nurse visits*	0.619 (-0.438 to 1.68)		0.481 (-1.24 to 2.20)	
Sensitivity analysis 2 Outcomes – including open prison				
	Step change	**Slope change**	**Step change**	**Slope change**
	Co-efficient (95% CI)	**Co-efficient (95% CI)**	**Co-efficient (95% CI)**	**Co-efficient (95% CI)**
Prisoner-on-staff assaults ǂ	N/A	N/A	-0.001 (-0.003 to 0.001)	-0.0001 (-0.0004 to 0.0002)
Prisoner-on-prisoner assaults ǂ	N/A	N/A	0.004 (-0.001 to 0.009)	-0.0008 (-0.002 to 0.00005)
Fires ǂ	0.0005 (0.00004 to 0.001)	0.00003(-0.00004 to 0.0001)	-0.009 (-0.002 to -0.000008)	-0.00004 (-0.0001 to 0.00007)
MORS ǂ	0.009 (0.0008 to 0.016)	0.0002 (-0.0006 to 0.001)	0.002 (-0.008 to 0.013)	-0.0001 (-0.001 to 0.001)
	Change Phase 1 v Phase 2			**Change Phase 2 v Phase 3**
Utilities Mean (SD) *	-0.007 (-0.022 to 0.008)		-0.044 (-0.063 to -0.026)	

ǂ time series analysis, * regression framework, MORS - The Management of an Offender at Risk due to any Substance

Appendix 6 Short-term cost-effectiveness and cost-utility analyses results

Supplementary Table 9 Cost-effectiveness and cost-utility analyses: costs breakdown

Resource	Presence of smoke-free policy £	Absence of smoke-free policy £
Base-case		
People in custody		
Health services resources		
GP/nurse visits	57	44
Inpatient	93	122
Outpatient	30	45
Mental health stays	2,599	2,548
A&E visits	18	18
Ambulance	16	8

Medication – smoking related illness	9	34
Medication – nicotine dependence	34	21
Personal		
Tobacco	-	302
E-cigarettes	219	-
Total for PiC	**3,075**	**3,142**
Operational staff		
GP visits	24	36
Tobacco	173	194
Total for staff	**197**	**230**
Sensitivity analysis 1 – all medication (PiC)		
Health services resources		
GP/nurse visits	57	44
Inpatient	92	122
Outpatient	30	45
Mental health stays	2,599	2,548
A&E visits	18	18
Ambulance	16	8
Medication – all	1,696	1,108
Personal		
Tobacco	-	302
E-cigarettes	219	-
Total	**4,727**	**4,195**
Sensitivity analysis 2 – including open prison (PiC)		
Health services resources		
GP/nurse visits	57	43
Inpatient	92	122
Outpatient	30	45
Mental health stays	2,599	2,548
A&E visits	18	18
Ambulance	16	9
Medication – smoking related illness	9	33
Medication – nicotine dependence	35	22
Personal		
Tobacco	-	299
E-cigarettes	216	-
Total	**3,072**	**3,139**

Supplementary Table 10 Cost-effectiveness and cost-utility analyses: sensitivity analysis

	Presence of smoke-free policy	**Absence of smoke-free policy**	**Difference**	**Cost-effectiveness**

Cost-effectiveness analysis (Incremental cost per 10µg/m^3 reduction in $PM_{2.5}$)				
Sensitivity analysis - all dispensed medication (person in custody)				
Person in custody				
Mean cost	£4,727	£4,195	£532	£151 per 10µg/m^3 reduction in $PM_{2.5}$
Mean $PM_{2.5}$ (10µg/m^3)	0.31	3.84	3.53	
Sensitivity analysis - including open prison data (person in custody)				
Person in custody				
Mean cost	£3,072	£3,139	-£67	Smoke-free policy dominates
Mean $PM_{2.5}$ (10µg/m^3)	0.31	3.84	3.53	
Cost-utility analysis (Incremental cost per quality adjusted life-year)				
Sensitivity analysis - all dispensed medication (person in custody)				
Person in custody				
Mean cost	£4,727	£4,195	£532	Absence of smoke-free policy dominates
Mean quality adjusted life-year	0.682	0.736	-0.054	
Sensitivity analysis - including open prison data (person in custody)				
Person in custody				
Mean cost	£3,072	£3,139	-£67	£1,241 per quality adjusted life-year
Mean quality adjusted life-year	0.685	0.736	-0.051	

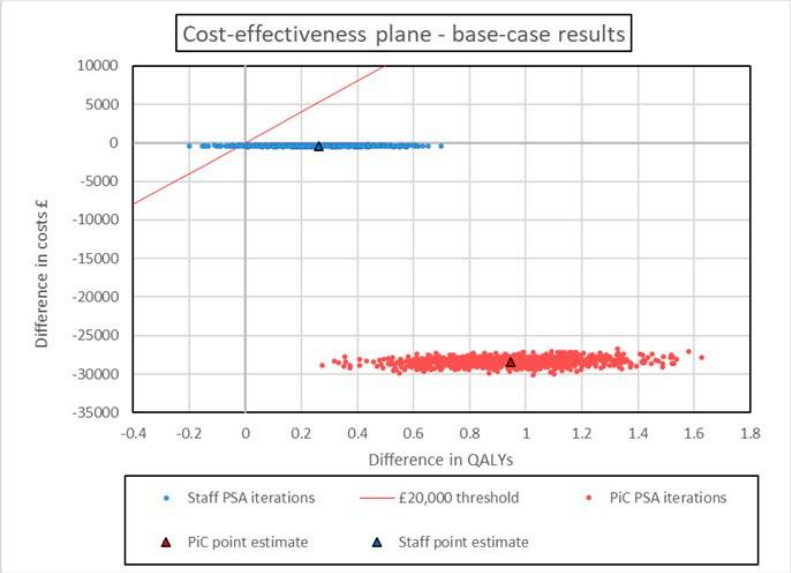
Appendix 7 Scenario (lifetime) analysis

Table 11 Scenario (lifetime) analysis: costs breakdown

People in custody		
Costs		
Implementation	£14	£0
Morbidity	£6,308	£7,079
Personal	£16,077	£43,759
Total costs	£22,399	£50,838
Staff		
Costs		
Implementation	£0	£0
Morbidity	£8,325	£8,337
Personal	£4,019	£4,467
Total costs	£12,343	£12,803

CI – confidence interval

Uncertainty is illustrated with results from the probabilistic sensitivity analysis plotted onto a cost-effectiveness plane (Supplementary Figure 1). This figure shows that there was minimal uncertainty in costs but more uncertainty in QALYs. It also shows that all plots for the PiC cohort demonstrate dominance of the smoke-free policy. In the staff cohort this uncertainty in QALY gains is illustrated by the plots crossing the vertical axis: a small proportion of the incremental QALYs fall to the left of the vertical axis (<1%), however, overall, there was an overall mean QALY gain.



Supplementary Figure 1 Scenario (lifetime) analysis: cost-effectiveness plane

Sensitivity analyses results

In all sensitivity analyses, the smoke-free policy dominates, confirming the robustness of the base-case results. Full results are reported in Supplementary Table 10 and ICERs are illustrated Supplementary Figure 2.

The analyses with the biggest impact on the ICER for PiC were Scenario 5 (*'Post-prison' tobacco spend: canteen 'in prison' data)* and Scenario 7 *(Replacing TIPs data with published data as far as possible).* These two scenarios reduce the ICER, although 'with a smoke-free policy' still dominates. In Scenario 5 the impact on the ICER is driven by the reduction in tobacco costs in the 'post-prison' period; in the base-case analysis tobacco costs after release from prison are based on the Office for National Statistics (ONS) cost which is higher than the cost of tobacco on sale in prison; taking account of this difference reduces the ICER from -£21,127 to -£3,013. Scenario 7 is driven by the assumption that 100% of those PiC who were tobacco smokers prior to the introduction of smoke-free policy will resume tobacco smoking on release from prison, compared to 42% in the base-case

analysis. This Scenario is also impacted by the change in published utilities. The combination of these changes in parameters results in lower incremental costs and QALYs than the base-case analysis, -£900 compared to -£21,127 and 0.126 compared to 0.639. Scenario 1 *(PiC resumption of smoking on release)* which replaces 42% of PiC resuming smoking with 95%, results in smaller incremental costs due to increased costs after release for personal spend on tobacco, and smaller incremental QALYs due to increased harm from increased tobacco smoking.

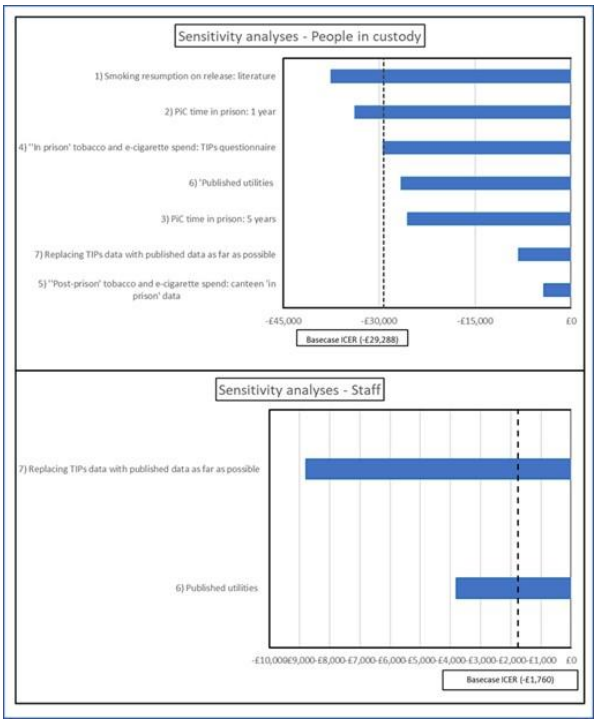
The sensitivity analysis with the biggest impact on the staff ICER was Scenario 7. This is driven by higher numbers of never smokers in the base-case analysis compared to the sensitivity analysis (91% compared to around 80%), resulting in lower incremental QALYs in the sensitivity analysis (0.094 compared to 0.229), and a larger difference in utility values between pre-policy and post-policy in the base-case analysis.

Supplementary Table 12 Scenario (lifetime) analysis: sensitivity analyses results

Scenario		**Presence of smoke-free policy**	**Absence of smoke-free policy**	**Incremental result**
	Base-case results			
	People in custody			
Total cost		£22,399	£50,838	-£28,440
QALYs		21.781	20.810	0.971
Cost per QALY				-£29,288
	Operational staff			
Total cost		£12,343	£12,803	-£460
QALYs		29.815	29.554	0.262
Cost per QALY				-£1,760
	1) PiC smoking on release			
	People in custody			
Total cost		£44,889	£50,838	-£5,949
QALYs		20.968	20.810	0.159
Cost per QALY				-£37,512
	2) PiC time in prison: 1 year			
	People in custody			
Total cost		£24,969	£54,956	-£29,987
QALYs		21.609	20.722	0.887
Cost per QALY				-£33,824
	3) PiC time in prison: 5 years			
	People in custody			
Total cost		£20,062	£47,001	-£26,939
QALYs		21.945	20.892	1.053
Cost per QALY				-£25,581
	4) 'In prison' tobacco and e-cigarette spend: TIPs survey			

	People in custody			
Total cost		£22,919	£51,429	-£28,510
QALYs		21.781	20.810	0.971
Cost per QALY				-£29,360
	5) 'Post-prison' tobacco spend: canteen 'in prison' data			
	People in custody			
Total cost		£8,758	£12,864	-£4,107
QALYs		21.781	20.810	0.971
Cost per QALY				-£4,229
	6) Published utilities (PiC and staff)			
	People in custody			
Total cost		£22,399	£50,838	-£28,440
QALYs		23.397	22.325	1.072
Cost per QALY				-£26,528
	Operational staff			
Total cost		£12,343	£12,803	-£460
QALYs		29.850	29.729	0.121
Cost per QALY				-£3,804
7) Replacing TIPs data with published data as far as possible				
People in custody				
Total cost		£45,946	£47,107	-£1,160
QALYs		22.776	22.635	0.141
Cost per QALY				-£8,224
Operational staff				
Total cost		£17,369	£18,322	-£953
QALYs		29.460	29.352	0.109
Cost per QALY				-£8,776

PiC; Person in custody, QALY; quality adjusted life-year



Supplementary Figure 2 Scenario (lifetime) analysis: sensitivity analyses (tornado diagram)

Table 13 Scenario (lifetime) analysis: population level analysis

	Presence of smoke-free policy	Absence of smoke-free policy	Difference (95% confidence interval)	95% confidence interval
People in custody (n=7,500)				
Total costs	£168,037,000	£381,288,000	-£213,251,000	-£220,113,000 to -£205,641,000
Total QALYs	163,356	156,074	7,282	3,950 to 10,208
Staff (n=3,244)				
Total costs	£40,041,000	£41,534,000	-£1,493,000	-£1,745,000 to -£1,210,000
Total QALYs	96,721	95,873	848	-63 to 1,844

QALYs – quality adjusted life-years

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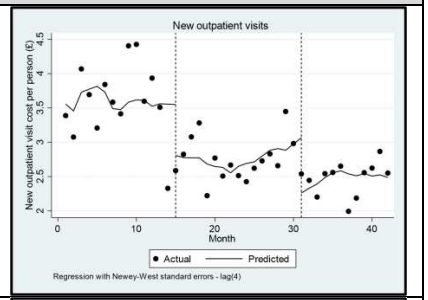
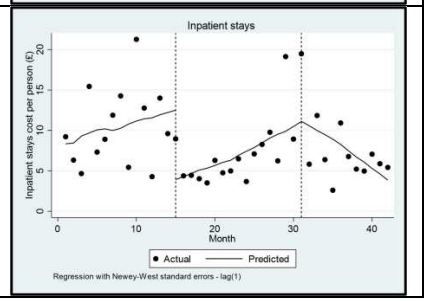
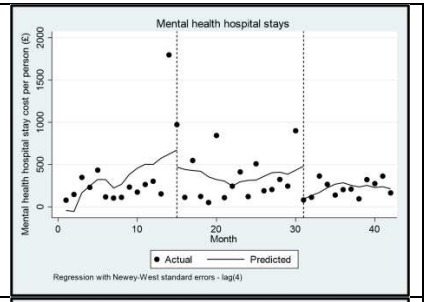
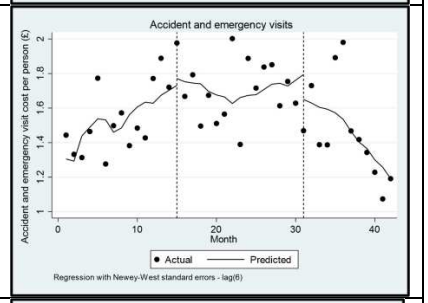
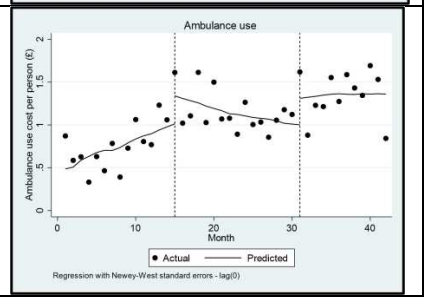
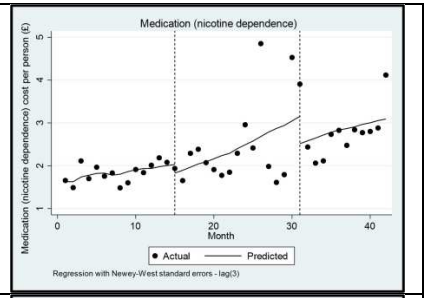
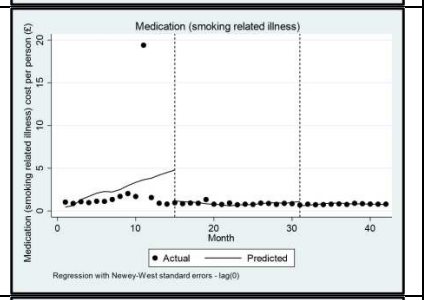
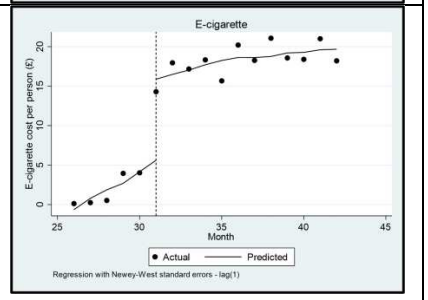
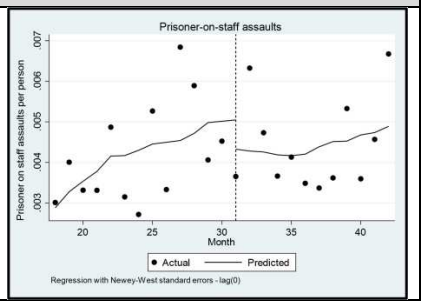
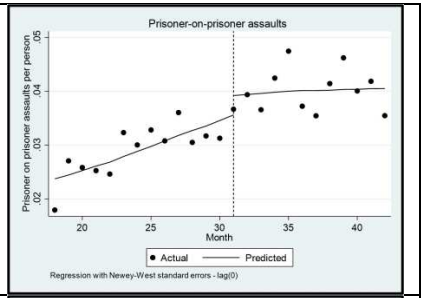
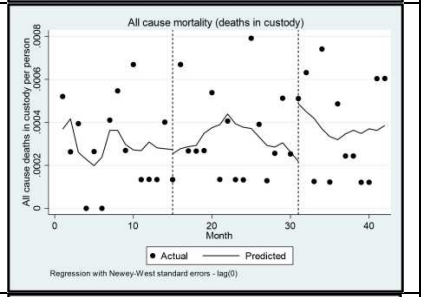
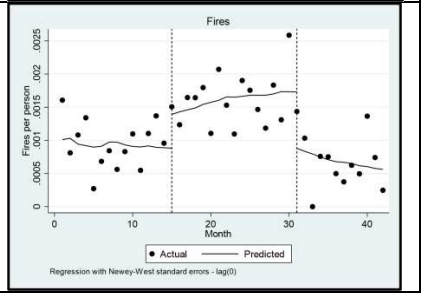
Supplementary Table 1 Cost-consequence analysis results: costs and outcomes (base-case)

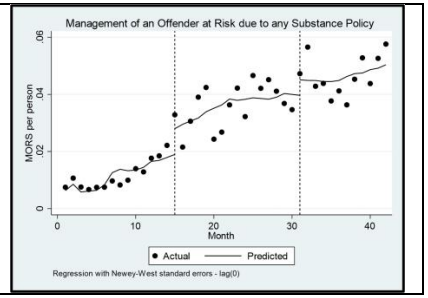
	Mean cost/outcome per person			Graphs from interrupted time series analysis
	Pre-announcement phase	**Preparatory phase**	**Post-implementation phase**	
Mean cost per person per month				
PiC outpatient visits ł	**£**3.61	**£**2.76	**£**2.48	
PiC inpatient stays ł	**£**10.40	**£**6.94	**£**7.71	

PiC mental health hospital stays ł	**£**321	**£**370	**£**217	
PiC accident & emergency visits ł	**£**1.53	**£**1.71	**£**1.46	
PiC ambulance use ł	**£**0.74	**£**1.15	**£**1.35	

PiC medication (nicotine dependence) ł	**£**1.83	**£**2.39	**£**2.83	
PiC medication (smoking related illness) ł	**£**2.55	**£**0.88	**£**0.79	
PiC e-cigarettes ł	N/A (not available to purchase from canteen)	**£**1.77	**£**18.26	
PiC GP/nurse visits *	£3.64 (SD 10.84) n=2354	£4.32 (SD 23.54) n=1783	£4.77 (SD 26.65) n=1336	

Staff GP visits *	£3.03 (SD 8.26) n=991	£2.67 (SD 7.88) n=1001	£1.99 (SD 5.89) n=513	
PiC tobacco *	£24.93	£24.93	N/A (no longer available to purchase from canteen)	
Staff tobacco *	£16.91 (SD 64.28) n=993	£16.96 (SD 58.54) n=1008	£15.98 (SD 58.08) n=514	
Outcome per person				
Levels of second-hand smoke (µg/m^3) Mean $PM_{2.5}$ (SD) across all prisons (not per person)*	38.44 (SD 55.54)	11.15 (SD 4.93)	3.14 (SD 5.06)	
Health utilities (PiC) Mean (SD) *	0.736 (0.248) n=2268	0.725 (0.246) n=1729	0.682 (0.270) n=1298	
Health utilities (staff) Mean (SD) *	0.859 (0.121) n=1002	0.862 (0.127) n=925	0.863 (0.135) n=455	
Prisoner-on-staff assaults ł †	Data not available	0.004	0.004	

Prisoner-on-prisoner assaults ł †	Data not available	0.029	0.040	
All-cause mortality (deaths in custody) ł †	0.0003	0.0003	0.0004	
Fires ł †	0.0009	0.0016	0.0007	

MORS ǂ †	0.011	0.036	0.046	

ǂ time series analysis; * regression framework; † mean number of events per person in custody per month; MORS - The Management of an Offender at Risk due to any Substance; PiC – person in custody; SD – standard deviation