Model-based economic evaluations in smoking cessation and their transferability to new contexts: a systematic review

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ABSTRACT

Aims To identify different types of models used in economic evaluations of smoking cessation, analyse the quality of the included models examining their attributes and ascertain their transferability to a new context. Methods A systematic review of the literature on the economic evaluation of smoking cessation interventions published between 1996 and April 2015, identified via Medline, EMBASE, National Health Service (NHS) Economic Evaluation Database (NHS EED), Health Technology Assessment (HTA). The checklist-based quality of the included studies and transferability scores was based on the European Network of Health Economic Evaluation Databases (EURONHEED) criteria. Studies that were not in smoking cessation, not original research, not a model-based economic evaluation, that did not consider adult population and not from a high-income country were excluded. Findings Among the 64 economic evaluations included in the review, the state-transition Markov model was the most frequently used method (n = 30/64), with quality adjusted life years (QALY) being the most frequently used outcome measure in a life-time horizon. A small number of the included studies (13 of 64) were eligible for EURONHEED transferability checklist. The overall transferability scores ranged from 0.50 to 0.97, with an average score of 0.75. The average score per section was 0.69 (range = 0.35–0.92). The relative transferability of the studies could not be established due to a limitation present in the EURONHEED method. Conclusion All existing economic evaluations in smoking cessation lack in one or more key study attributes necessary to be fully transferable to a new context.

Keywords Economic evaluation, modelling, smoking, systematic review, tobacco, transferability.

INTRODUCTION

The core strategies in reducing smoking prevalence are to prevent people from starting smoking, to reduce the number of smokers and to decrease the chances of relapse. This can be achieved by implementing population-based tobacco control policies (e.g. legislations and mass media campaigns) and smoking cessation programmes (e.g. drug or behavioural therapies) targeted at current smokers. However, due to the increasing number of interventions now available, decision-makers face difficulties in deciding which intervention to implement. Given scarce resources, relative costs and benefits of those interventions are one of the key decision-making criteria, thus making the importance of economic evaluations rise in recent years [1,2]. Economic evaluations combine the outcomes of interventions with their costs, in order to determine which intervention provides the best value for money [3]. Such evaluations, for example, have shown that treatment with varenicline [4,5] or behavioural support by mobile phone [6] can be cost-effective. Model-based economic evaluations are especially appropriate to extrapolate the benefits beyond clinical trials and when a single primary source of data is not sufficient [7]. In addition, a model-based economic evaluation has the ability to adapt itself to a new context, making the process of executing economic evaluations less time-consuming and thus less costly [8,9]. Unfortunately, such evaluations often originate in affluent societies. The number of lives that can be saved from the use of such evidence elsewhere (e.g. countries in Central
and Eastern Europe) is potentially enormous. Sadly, these countries often have too limited research resources to study cost-effectiveness of such interventions in their own context, highlighting the importance of transferability assessments [9,10].

The notion of transferability of evidence from one context to others varies widely in the literature. ‘Transferability’, ‘generalizability’ and ‘external validity’ are the concepts used to assess the ability of a study to be relevant to the decision maker’s context to the extent the findings could actually be used [11–15]. However, a distinction also exists between what is feasible/applicable and what is generalizable/transferable. Applicability refers to ‘how can I replicate the intervention in my own decision context?’ (the process question) and generalizability refers to ‘whether the effectiveness will be similar to that in the original context?’ (the outcome question) [12,13,15,16]. Therefore, these two underlying questions seem to have defined transferability in the literature.

Transferability assessments to date have focused mainly on the way in which a model is constructed and populated, as modelling provides a well-defined structure helping us to recognize the limitations and their implications for generalizability of the results [7,17–19]. There has not been a systematic enquiry in to the transferability of economic evaluations in smoking cessation, although a few systematic reviews in this area exist [20,21]. The review by Kirsch et al. [21], for instance, limits itself to a narrow definition of study population and to a specific type of economic model. In this paper, we therefore set out to: (i) identify different types of models used in economic evaluations of smoking cessation; (ii) analyse the quality of the included models examining their attributes; and (iii) ascertain their transferability to a new context.

**METHODS**

**Search strategy and implementation**

A systematic search was conducted to identify all relevant models used for economic evaluation in smoking cessation on the following databases: National Health Service (NHS) Economic Evaluation Database (NHS EED), Health Technology Assessment (HTA), Medline and EMBASE. They were searched for publications in English language between 1996 and April 2015. The search strategy was based on related published systematic reviews [20,22–24], leading to the final search terms ‘smoking’, ‘nicotine’ and ‘tobacco’ in NHS EED and HTA. Medline and EMBASE required additional terms related to model-based economic evaluation, which were based on Wilczynski et al. [25] and McKinlay [26] to acquire high sensitivity as well as high specificity [27]. Supporting information, Table S1 shows an overview of the search strategies used by databases.

All results were exported to EndNote (Thomson Reuters) version X7, where duplications were removed automatically and remaining duplicates checked manually.

**Exclusion criteria and screening**

Title and abstract screening for the first 50 papers was performed independently by two reviewers (M.H. and M.B.) based on the following exclusion criteria: (1) topic not in smoking cessation (as the focus was on the interventions to reduce tobacco use), (2) no original research (to avoid inclusion of review of evidence or opinion pieces), (3) no model-based economic evaluation (to avoid inclusion of other designs, e.g. trial-based evaluations), (4) no adult general population (to focus on adults, rather than children), (5) no high-income country (to reduce study heterogeneity by including comparable, industrialized countries based on their income levels) and (6) not available in the English language (practicality reasons mainly to address resource constraints). No differences in exclusion/inclusion were observed between both reviewers; only minor discrepancies were recorded in the reason of exclusion. The inter-rater reliability (IRR) gave a Cohen’s kappa of 0.912, meaning almost perfect agreement [28]. Remaining discrepancies were discussed, leading to full agreement. Screening of the remaining papers was then completed by one researcher (M.B.). Full text screening was performed independently by two reviewers (M.B. and K.L.C. or M.H.). There were only minor discrepancies between the reviewers, which led to full agreement after discussion. Supporting information, Tables S2 and S3 show an extended list of exclusion criteria for full-text screening.

**Data extraction**

Data on the following items were extracted using an Excel template adapted from published studies [20,29,30] and included: study attributes (type of evaluation, interventions, comparator and country); model (type, transition or health states, time horizon and perspective); effectiveness (outcome and discount rate, primary measure of effectiveness and utility valuations); costs (perspective, categories, resource, index year and discount rate); uncertainty (type and outcome of sensitivity analysis); and results and major limitations.

As data from some included studies were already extracted by the University of York’s Centre for Reviews and Dissemination (CRD) (n = 39 of 64), only one researcher (M.B.) extracted data independently on those studies and compared with the CRD extraction. The CRD database contains clear and structured summaries of the economic analyses by experts, and therefore it was deemed sufficient to compare the results of data extraction to these summaries. For the remaining studies that were not
included in the CRD database, the data were extracted independently by two reviewers (M.B. and one of the following: M.H., K.L.C., R.D.K. and P.K). Any disagreement between the reviewers was resolved by consensus with a third reviewer.

**Quality appraisal**

In order to appraise the quality, 10% of the included studies were first assessed independently by M.B. and M.H., using a quality checklist and corresponding classification from the National Institute for Health and Care Excellence (NICE) Methodology Guide with the aim to filter out quality-poor studies [31]. The quality checklist was based on three major criteria: (1) the study was conducted from a relevant perspective (i.e. at least payer or health-care perspective); (2) the study was a cost–utility or cost–benefit analysis with cost/utility adjusted life years (QALY) or benefit–cost ratio reported; and (3) limitations, either stated in the original study or identified by the reviewers during data extraction stage. Once the overall assessment using these criteria was completed, the studies were assigned to one of the following three classifications: (i) a study with minor limitations (ML); (ii) a study with potentially serious limitations (PSL); or (iii) a study with very serious limitations (VSL). As full agreement on quality classification was reached in the 10% of the included studies, M.B. then completed the quality appraisal of the remaining studies.

**Transferability assessment**

The studies appraised as the one with minor limitations (ML) were considered to be of sufficient quality to be included for transferability assessment applying the EURONHEED checklist [9]. Two independent researchers (M.B. and one of the following: M.H., K.L.C., R.D.K. and P.K.) applied the checklist. The EURONHEED checklist was developed originally by Boulenger et al. [9] and described and updated further with guidelines by Nixon et al. [32]. It consists of 42 questions, 26 of which relate to overall methodological quality and internal validity, and 16 questions relate to transferability. An overview of all questions is provided in Supporting information, Table S4. Every question can be answered by ‘yes’/partially/‘no’ or not applicable (NA), assigning a score of 1, 0.5 and 0, respectively. While each item in the checklist is treated equally (but implicitly giving more weight to 16 of the 42 items), the assigned score to each question thus additionally provides another weight to reflect the extent to which each item was reported in the study being assessed [32]. The combination of the questions generates an overall summary score [9,10]. We calculated two summary scores: the total summary score including all 42 items and the transferability score including the 16 items. The summary scores were calculated using the following formula: \[ \frac{1}{n} \sum_{i=1}^{n} S_i \times 100, \] in which \( n \) is the number of questions, \( x \) is the number of questions for which the response was NA and \( S \) is the score of each question [9]. The summary scores reflect how thoroughly key methodological items are reported as the quality of reporting is paramount for generalizability/transferability [32]. In addition to this, we calculated the scored percentage of the total score possible per section. This showed us what sections within model-based economic evaluations were of sufficient quality and which needed further improvement. For example, a score of 0.75 means that 75% of this section is of sufficient quality.

**RESULTS**

**Search outcomes**

The systematic literature search yielded 1925 references. After removing duplicates, 1500 studies were included for title and abstract screening which led to a total of 101 studies selected for full text screening. On applying the exclusion criteria, 64 studies were judged to be eligible for data extraction. Thirteen of the 64 studies were included for transferability assessment. An overview of the process is provided in Fig. 1.

**Overview of studies**

An overview of the identified models is shown in Table 1. Most studies originated from Europe (\( n = 30 \) of 64) and the United States (\( n = 24 \) of 64), followed by Australia (\( n = 4 \) of 64) and Asia (\( n = 2 \) of 64). Three of 64 studies were multi-continental.

The populations in the analyses were described mainly as the general adult population of smokers. In three studies the populations were described further as smoking 20 cigarettes per day or more [33–35], making or considering a single or first quit attempt [36–39] or had recently tried to quit smoking [40,41]. In five studies the population was described only as a dynamic and/or hypothetical cohort [42–46] and in nine studies the population was not reported at all [47–55].

A significant part of the intervention was smoking cessation programmes, either pharmacotherapy [4,5,36–38,40,41,48,50,51,53,55–65], behavioural therapy [6,42,47,66–69] or a combination of these [33–35,43,45,46,49,52,54,70–75]. Several studies evaluated wider tobacco control interventions [39,44,76–88], whereas five studies included both smoking cessation programmes and tobacco control interventions [89–93].

In a number of studies, the authors selected ‘no intervention’ or ‘current situation’ as comparator. All other studies described the comparators in more detail (Table 1).
The main measure of outcome used is the QALY. In total, 23 of 64 studies reported QALY as their main outcome \[5,35,38,40,41-49,56,58,59,61-63,65,69,70,76,78,81,86,88,94\], followed by life years (LY) gained \(n=9\) of 64 \[33,43,46,66-68,73,74,89\] or a combination of these \(n=12\) of 64 \[4,6,35-37,39,42,44,57,77,80,83\]. Five of 64 studies reported disabilty adjusted life years (DALY) as their main outcome \[60,82,90-92\], and only four of 64 (incremental) net benf \[52,53,55,71\]. There were two of 64 studies reporting only the intermediate outcomes of the intervention \[85,93\] (Table 1).

Overview of economic models

Table 2 shows the main model attributes used in the included studies. Thirty of 64 studies used a Markov model, 12 of which used a specific type called the benefits of smoking cessation on outcomes (BENESCO) model \[4,5,36,37,48,56-59,61,62,65\]. Decision-tree models \[41,43,52,55,63,71,75,83,93\], discrete-event simulations (DES) \[45,54\], the chronic disease model (RIVM-CDM) \[44,81,88\], the tobacco policy model (TPM) \[76,77\], the quit benefits model (QBM) \[80\], the World Health Organization (WHO) model \[90\], the global health outcomes model (GHO model) \[70\] and the abstinent-contingent treatment model (ABT model) \[73\] were also used. Twelve of 64 studies did not report explicitly the model used, reporting only decision analysis modelling or simulation modelling \[39,50,51,66,69,72,74,78,86\] or limiting the description to only dynamic or static modelling \[42,82,92\].

Several (18 of 30) studies based on Markov models provided sufficient information on transition or health states used in the model. The most frequently used transition states were current smoker, former smoker or death, while health states included asthma exacerbation, coronary heart disease (CHD), stroke, chronic obstructive pulmonary disease (COPD) and lung cancer. In decision-tree models \(n=9\) of 64 the most reported transition states were quit attempt or no quit attempt, often combined with success to quit or failure to quit.
| Author, year | Country                  | Population                              | Intervention                                             | Comparator                                                                 | Outcome |
|-------------|--------------------------|-----------------------------------------|----------------------------------------------------------|--------------------------------------------------------------------------|---------|
| Ahmad, 2005a | CA, USA                  | General Californian population          | Raising legal smoking age from 18 to 21                  | Legal smoking age 18, 19, 20                                              | QALY    |
| Ahmad, 2005b | USA                      | General American population             | Raising legal smoking age from 18 to 21                  | No intervention                                                          | LY gained and QALY |
| Annemans, 2015 | Belgium                 | 18+ Belgian smokers                     | Varenicline in retreatment                               | No treatment, and retreatment with bupropion or NRT                      | QALY    |
| Annemans, 2009 | Belgium                 | 18+ Belgian smokers                     | Varenicline                                               | Pharmacotherapies, brief counselling and unaided cessation              | QALY    |
| Athanasakis, 2012 | Greece                | 18+ Greek smokers                      | Varenicline                                               | Bupropion, NRT and unaided cessation                                      | QALY    |
| Bae, 2009     | South Korea              | General Korean population               | Varenicline                                               | NRT, bupropion and no drugs                                              | QALY    |
| Bauld, 2011   | Scotland                 | Not reported                            | One-to-one counselling or group-based support programme  | No intervention                                                          | QALY    |
| Bertram, 2007 | Australia                | Australian smokers aged 20–79           | NRT or bupropion                                          | No intervention                                                          | DALY    |
| Bolin, 2006   | Sweden                   | Swedish smokers aged 35+                | Bupropion tablets with four nurse visits for motivational | No intervention                                                          | QALY    |
| Bolin, 2008   | Sweden                   | Swedish smokers aged 18+                | Varenicline                                               | Bupropion                                                               | QALY    |
| Bolin, 2009a  | Sweden                   | Swedish adult population                | 12-week varenicline treatment expanded with 12 weeks of  | 12 weeks of varenicline                                                  | QALY    |
| Bolin, 2009b  | Belgium, France, Sweden  | Not reported                            | Maintenance with varenicline                             | +12 weeks of placebo                                                     | QALY    |
| Boyd, 2009    | UK                       | Glasgow smoking population              | Varenicline                                               | NRT                                                                      | QALY    |
| Brown, 2014   | England                  | 16+ without having quit successfully in the last month | 'Starting fresh' and 'Smoking concerns' | Self-quit                                                               | QALY    |
| Cantor, 2015  | USA, Texas               | Physicians and pharmacists from 16 communities in Texas Participants: 18+ | The health-care team approach to smoking cessation: ETOEP  | Usual practice                                                           | QALY    |
| Chevreul, 2014 | France                   | Insured current French smokers aged 15–75 years | Full coverage of the medical management of smoking cessation | Current situation                                                        | ICER per LY gained |
| Cornuz, 2006  | Canada, France, Spain, Switzerland, UK, USA | Smokers smoking > 20 cigarettes per day | Four NRTs (gum, patch, spray, inhaler) and bupropion, given as adjunct to cessation counselling | Not Reported                                                             | LY gained |
| Cornuz, 2003  | A European country (some data used from Switzerland) | Smokers smoking > 20 cigarettes per day | Four NRTs (gum, patch, spray, inhaler) and bupropion, given as adjunct to cessation counselling | GP counselling during routine visit                                      | Incremental cost per LY gained |
Table 1. (Continued)

| Author, year | Country          | Population                          | Intervention                                      | Comparator                                         | Outcome              |
|--------------|------------------|-------------------------------------|---------------------------------------------------|---------------------------------------------------|----------------------|
| Croghan, 1997 | USA, Rochester   | Smokers aged 18+                    | Non-physician smoking cessation counselling       | No intervention                                   | LY gained            |
| Dino, 2008   | USA              | Adolescents aged 17–25 years        | American Lung Association’s Not On Tobacco national teen smoking cessation programme | Brief intervention                                 | Discounted LY        |
| Feenstra, 2005 | The Netherlands  | Dynamic population                  | Face-to-face smoking cessation interventions      | Current situation                                  | LY gained and QALY   |
| Fiscella, 1996 | USA              | Not reported                         | Nicotine patches as an adjunct to physician-based counselling | Physician-based counselling                       | QALY                 |
| Guerriero, 2013 | UK               | Smokers aged 16+                    | Text-based support in adjunct to current practice | Current situation                                  | LY gained and QALY   |
| Halpern, 2007a | USA              | Not reported                         | Varenicline                                       | Nicotine patch, bupropion, and no pharmacotherapy | ROI, IRR, B–C-ratio  |
| Halpern, 2007b | USA              | Reflection of US population          | Work-place smoking cessation coverage             | No coverage                                        | IRR, ROI             |
| Heitjan, 2008 | USA              | American whites                     | Nicotine patch, bupropion, varenicline and tailored therapy based on genetic testing | No intervention                                   | Residual LY          |
| Hill, 2006    | USA              | Not reported                         | NRF (gum, patch, inhaler, nasal spray), Zyban or combinations | No intervention                                   | ICER                 |
| Hojgaard, 2011 | Denmark          | General Danish population           | Smoking cessation programme and a smoking ban     | Current situation                                  | LY gained            |
| Hoogendoorn, 2008 | The Netherlands  | General Dutch population            | Varenicline                                       | No intervention, bupropion, nortriptyline or NRF  | Number of quitters, LY gained, and QALY |
| Howard, 2008  | USA              | US adult 18+ population              | Varenicline                                       | Bupropion, NRT, and unaided quitting              | QALY                 |
| Hurley, 2008  | Australia        | General Australian population        | Australian National Tobacco Campaign              | Current situation                                  | LY gained and QALY   |
| Igarashi, 2009 | Japan            | Japanese smokers aged 20+ smoking >20 cigarettes per day | Varenicline combined with counselling             | Counselling                                       | QALY                 |
| Jackson, 2007 | USA              | Not reported                         | Varenicline                                       | Bupropion                                         | Net benefit          |
| Knight, 2010  | USA              | General American population making single quit attempt | Varenicline 12 + 12 weeks                        | Bupropion, NRT and unaided cessation              | QALY                 |
Table 1. (Continued)

| Author, year | Country | Population | Intervention | Comparator | Outcome |
|--------------|---------|------------|--------------|------------|---------|
| Lai, 2007    | Estonia | Estonian smokers aged 15–59 | Increase of tax, clean indoor air law enforcement, and NRT | No intervention (do-nothing counterfactual) | DALY |
| Lal, 2014    | Australia | Smokers aged 35–100 | Telephone counselling | Self-help | DALY |
| Levy, 2006   | USA | Employees aged 18–64 | Four coverage scenarios | No coverage | Changes in medical expenditures |
| Levy, 2002   | USA | Hypothetical cohort of smokers | Coverage of costs of different combinations of treatment, and brief interventions by care providers | No intervention | Quit rates |
| Linden, 2010 | Finland | Finnish adult smokers making a first quit attempt | Varenicline | Prescribed medicine, bupropion or unaided cessation | QALY |
| McGhan, 1996 | Not reported | Not reported | Self-care, behavioural therapy, group withdrawal clinic or nicotine patch | Not reported | Net benefit |
| Nielsen, 2000 | USA | Smokers enrolled on a smoking cessation programme | Nicotine patch, bupropion, or combination | Placebo | Net benefit |
| Nohlert, 2013 | Sweden | General Swedish population | Low and high intensity smoking cessation program | No intervention | QALY |
| O’Donnell, 2011 | USA | Dynamic population | Cold turkey, behavioural therapy, medication therapy or combinations | No intervention | LY gained |
| Olsen, 2006  | Denmark | General Danish population | Group courses, individual courses or quick interventions | No intervention | LY gained |
| Ong, 2005    | USA, Minnesota | Minnesota population of smokers | Free NRT | State-wide campaign of smoke-free work-places | QALY |
| Oer, 2014    | The Netherlands | Dutch smokers aged 25–80 | Tax increase or reimbursement | Current situation | QALY |
| Pinget, 2007 | Switzerland | Swiss smokers | Physician training in smoking cessation counselling | Physician training in dyslipidaemia management | LY gained |
| Ranson, 2002 | 139 countries | Current smokers in 1995 | Tobacco control policies (price increases, NRT, non-price interventions) | No tobacco control policy | DALY saved |
| Shearer, 2006 | Australia | General Australian population | Brief advice, telephone counselling, NRT or bupropion | No intervention, brief advice, counselling or pharmacotherapies | ICER |
| Simpson, 2013 | USA | New York State aged 18+ | New York Tobacco Control Programme | No intervention | Smoking costs avoided |
| Song, 2002   | UK | Hypothetical cohort of smokers | Advice plus NRT, advice plus bupropion or advice plus NRT and bupropion | Advice or counselling only | LY gained |
| Author, year | Country | Population | Intervention | Comparator | Outcome |
|--------------|---------|------------|--------------|------------|---------|
| Stapleton, 1999 | UK | Smokers in general | Transdermal nicotine patches with GP counselling | GP counselling | LY gained |
| Stapleton, 2012 | Data used from USA and UK | Smokers in general | Cytisine, Agency for Health Care Policy and Research Guideline for smoking cessation, NICE appraisal of NRT, or effect size given as an odds ratio or relative rate of NRT, bupropion or varenicline | Placebo | LY gained |
| Taylor, 2011 | UK | Hypothetical cohort of smokers who recently initiated quit attempts | NRT, bupropion or varenicline | No drug therapy | QALY |
| Tran, 2002 | USA, Virginia | Smokers aged 21–70 who tried (at least once) to quit smoking | Cold turkey, nicotine patch, nicotine gum or bupropion | Self-quit | QALY |
| Van Baal, 2007 | The Netherlands | Dynamic population | Tobacco tax increase | Current situation | LY gained and QALY |
| Van Genugten, 2003 | The Netherlands | Dutch population | Policy measures (‘Don’t start’, ‘quit’, ‘tax’) | Future smoking prevalence is based on trend extrapolation | DALY |
| Vemer, 2010a | The Netherlands, Belgium, Germany, Sweden, France, and UK | Smokers aged 18+ in the Netherlands, Belgium, Germany, Sweden, France and the UK | NRT, bupropion or varenicline | Unaided quit attempt | QALY |
| Vemer, 2010b | The Netherlands | Dutch smokers aged 18+ | Smoking cessation support | Current situation | QALY |
| Von Wartburg, 2014 | Canada, France, Spain, Switzerland, UK, USA | Cohort representative of Canadian demographics, smokers who seriously consider quitting within the next 30 days | Standard 12 weeks of varenicline, or 12 + 12 weeks of varenicline | Bupropion, NRT, or unaided cessation | QALY |
| Warner, 1996 | USA | Hypothetical cohort of blue-collar workers | Work-site smoking-cessation programme | No intervention | LY gained, medical expenditures saved |
| Welton, 2008 | UK | Not reported | Genetic testing of DRD2 Taq1A NRT, bupropion, their combination, or standard care | Brief advice or individual counselling | Incremental net benefit |
| Xenakis, 2009 | USA | Not reported | Varenicline with counselling | Counselling + bupropion or placebo | Incremental costs |
| Xu, 2014 | USA | US adult 18+ population | Anti-smoking campaign | No campaign | LY gained and QALY |

NRT = nicotine replacement therapy; QALY = quality adjusted life years; DALY = disability adjusted life years; NICE = National Institute for Health and Care Excellence; GP general practitioner; ICER = incremental cost-effectiveness ratio; LY = life years; IRR = inter-rater reliability; ROI = return on investment; B-C = benefit-cost.
| Type of model | Study | Transition/health states<sup>a</sup> | Time-horizon | Perspective | Characteristics | Discounting | Analysis | Sensitivity analysis<sup>b</sup> |
|--------------|-------|----------------------------------|--------------|-------------|----------------|-------------|----------|-----------------------------|
| Markov (n = 30) | Annemans, 2015 | 4 | Life-time | Health-care payer | 1.5% | Costs | Abstinence rates | USA and PSA |
| | Annemans, 2009 | 4 + 6 | Life-time | Health-care payer | 1.5% | 3% | Continuous abstinence rates | USA and PSA |
| | Athanasakis, 2012 | 5 | Life-time | Societal | 3% | 3% | Continuous abstinence rates | PSA |
| | Bae, 2009 | NR | Life-time | NR | 5% | 5% | Quit rates | USA and PSA |
| | Bertram, 2007 | 3 | Life-time | Health-care system | 3% | 3% | Probability of cessation | DSA and PSA |
| | Bolin, 2008 | NR | 20 and 50 years | Health-care and societal | 3% | 3% | Smoking prevalence and quit rates | USA, MSA, and PSA |
| | Bolin, 2009a | NR | 50 years | NR | 3% | 3% | Odds ratio for quitting | USA |
| | Bolin, 2009b | SC intervention +4 | Life-time | Health-care system | 3.5% | Costs | Continuous abstinence rates | DSA, MSA, and PSA |
| | Chevreul, 2014 | 3 | Life-time | Social Health Insurance | 3% | 3% | Quit rates | DSA, PSA |
| | Cornuz, 2006 | NR | Life-time | NR | NR | 3% | Odds ratio for quitting | USA |
| | Cornuz, 2003 | NR | Life-time | Third-party payer | 3% | 3% | Odds ratio for quitting | NR |
| | Dino, 2008 | Current smoker, quit, reduce, stay smoker | Life-time | School | 3% | 3% | Quit rates | MSA and ECA |
| | Fiscella, 1996 | NR | Life-time | Health-care payer | 3% | 3% | Cessation rates | USA and PSA |
| | Guerriero, 2013 | 3 + ML, CHD, stroke, lung cancer, COPD | Life-time | Health service (UK NHS) | 3.5% | Costs | Relative risk of quitting, relapse rates | DSA and PSA |
| | Heitjan, 2008 | NR | Life-time | NR | NR | 3% | Initiation rates and successful quit attempts | USA and ECA |
| | Hoiggaard, 2011 | 2 | 10 years and life-time | Societal | 3.5% | 3.5% | Quit and relapse rates | ECA |

<sup>a</sup> Characteristics showed per model and summary of most reported characteristics.

<sup>b</sup> Sensitivity analysis: PSA, MSA, DSA.
Table 2. (Continued)

| Type of model | Study   | Transition/health states\(^a\) | Time-horizon | Perspective          | Discounting | Analysis                                 | Sensitivity analysis\(^b\) |
|---------------|---------|--------------------------------|--------------|----------------------|-------------|------------------------------------------|---------------------------|
|               |         |                                |              |                      | Effects | Costs | Primary measure of effectiveness            |                           |
|               |         |                                |              |                      |          |       |                                           |                           |
|               | Hoogendoorn, 2008 | 4 + 6               | Life-time | Health-care payer                   | 1.5%  | 4%   | Abstinence rates                          | USA and PSA               |
|               | Howard, 2008       | 4 + 6               | Life-time | Health-care system                   | 3%   | 3%   | Continuous abstinence rates                | USA and PSA               |
|               | Igarashi, 2009     | Success-alive, failure-alive, sick-smoke, sick-non-smoke, death | Until age 90 | Health-care payer                   | 3%   | 3%   | Abstinence rates                          | USA, MSA, and PSA         |
|               | Knight, 2010 NR    | 3 + Mortality due to: cancer, COPD, CHD, stroke, other diseases | Life-time | NR                            | 3%   | 3%   | Quit rates                                 | USA and PSA               |
|               | Lal, 2014 Life-time | NR                  | Life-time | Health sector                   | 3%   | 5%   | Quit rates                                 | PSA                       |
|               | Levy, 2006 20 years | NR                  | Life-time | Employer                       | NR    | 5%   | Probability of smoking cessation          | DSA                      |
|               | Linden, 2010 4 + 6 | Life-time | Life-time | Societal                       | 5%   | 5%   | Continuous abstinence rates                | USA, MSA, and PSA         |
|               | Olsen, 2006 3     | Life-time | Life-time | Payer                         | 3.5% | 3.5% | Abstinence rates                          | USA and PSA               |
|               | Pinget, 2007 NR    | Life-time | Life-time | Third-party payer               | NR   | 3%   | Point abstinence at 1 year                 | USA                      |
|               | Simpson, 2013 Quit or continue smoking | 20 years | NR |                   | 3%   | 3%   | Rates for media awareness and quitline and (NYTCP) NRT utilization rates | NR                       |
|               | Taylor, 2011 Recent quitter, smoker (lung CA, CHD, MI, stroke, COPD), former smoker (lung CA, CHD, MI, stroke, COPD), dead | Life-time | Life-time | Health service (UK NHS) | 3.5% | 3.5% | Abstinence rates                          | USA                      |
|               | Vemer, 2010a 4     | Life-time | Life-time | Health-care system                   | 0–5.0% | 3.0–5.0% | Change in incremental net monetary benefits | NR                      |
|               | Von Wartburg, 2014 | Exclusive health states as a function of their demographics and smoking status | Life-time | Health-care system and societal        | NR    | 5%   | Quit rates                                 | USA and PSA               |
| Type of model          | Study         | Characteristics                                                                 | Transition/health states | Time-horizon | Perspective | Discounting | Analysis | Sensitivity analysis |
|-----------------------|---------------|---------------------------------------------------------------------------------|--------------------------|--------------|-------------|-------------|----------|---------------------|
| Most reported         | Welton, 2008  | NR                                                                              | Life-time                | Health service (UK NHS) | Not discounted | Abstinence rates | MSA and PSA |
|                       |               | NR (n = 11), 4 (n = 3) and combined with 6 (n = 4)                              |                          | NR           |             |             |          |
| Decision-tree model   | Boyd, 2009    | NR                                                                              | Life-time (n = 21)       | Health-care system/payer (n = 17) | Not discounted | Quit/abstinence rates (n = 24) | USA with PSA |
| (n = 9)               |               | 4 or 52 weeks                                                                  | Health service (UK NHS) | NR           | Not required | Predicted quit rates | USA and MSA |
|                       | Levy, 2002    | Quit attempt or no quit attempt, quit or fail                                  | 1 year                   | Health-care payer | NR           | Quit rates | USA and MSA |
|                       | McGhan,       | NR                                                                              | NR                       | Employer     | NR           | Quit rates | NR       |
| 1996                  |               |                                                                                     |                          | NR           | Not required | Continuous abstinence rates | USA       |
|                       | Nielsen,      | NR                                                                              | NR                       | Employer     | NR           | Quit rates | USA      |
| 2000                  |               |                                                                                     |                          | Health service (UK NHS) | NR           | Quit rates | ECA      |
|                       | Song, 2002    | NR                                                                              | NR                       | Payer        | 3%           | Quit rates | USA      |
|                       | Tran, 2002    | Quit attempt or no quit attempt, quit or fail, resume                           | 1 year                   | NR           | Not required | Continuous abstinence rates | NR       |
|                       | Halpern,      | Quit attempt or no quit attempt, quit or fail, resume                           | 2, 5, 10 or 20 years     | NR           | 3%           | Quit rates | NR       |
| 2007b                 | Jackson, 2007 | Quit or continue smoking                                                        | 1 year                   | Employer     | NR           | Continuous abstinence rates | NR       |
|                       | Xu, 2014      | Current smoker, quit attempt or continue smoking                               | NR                       | Funding agency | 3%           | Quit rates | USA      |
| Most reported         | Bauld, 2011   | Quit attempt or no quit attempt, (quit or fail) (n = 4)                          | Short-term (n = 5)       | Health-care system/payer (n = 4) | 3% (n = 2) | Quit/abstinence rates (n = 9) | USA (n = 3) or in combination with MSA (n = 2) |
| Remaining models      |               | Ex-smoker, smoker, death and smoking-related death                              | 1 year or life-time      | Health service (UK NHS) | 3.5% | Continuous abstinence rates | DSA      |
| reported (n = 25)     |               |                                                                                     |                          |              | NR           |             |          |
| Type of model          | Study               | Characteristics                                                                 | Transition/health states | Time-horizon | Perspective               | Discounting | Analysis                     | Sensitivity analysis |
|-----------------------|---------------------|-------------------------------------------------------------------------------|--------------------------|--------------|---------------------------|-------------|------------------------------|----------------------|
| DES                   | Warner, 1996        | NR                                                                            | 50 years                 | Societal and employer | NR            | 3%, 3.5%, 4%                | Quit rates            | USA and ECA          |
|                       | Xenakis, 2009       | NR                                                                            | 1 year                   | Health-care payer | NR            | Not required               | Continuous abstinence rates | USA                |
|                       | Over, 2014          | 1 + age, gender, SES                                                          | 75 years                 | Health-care system | NR            | 1.5% and 4%                | Quit rates            | USA and MSA          |
|                       | Van Baal, 2007       | 1 + 14-smoking related chronic diseases                                       | 100 years                | Health-care system | NR            | 1.5% and 4%                | Price elasticity of tobacco consumption | USA                |
|                       | Vemer, 2010b        | NR                                                                            | 20 years and lifetime    | Health-care system | NR            | 1.5% and 4%                | Additional number of successful quitters | NR                 |
| TPM                   | Ahmad, 2005a        | 1                                                                             | 50 years                 | Societal        | NR            | 3%                        | Initiation rates       | NR                  |
|                       | Ahmad, 2005b        | 1                                                                             | 50 years                 | Societal        | NR            | 3%                        | Initiation rates       | USA                  |
| QBM                   | Hurley, 2008        | NR                                                                            | Life-time                | NR             | 3%                        | Reduction in smoking prevalence   | DSA, MSA, and PSA |
| WHO model             | Lai, 2007           | NR                                                                            | 100 years                | Societal        | NR            | 3%                        | Change in disease incidence | ECA                |
|                       | Bolin, 2006         | 4                                                                             | 20 years                 | Health-care     | NR            | 3%                        | QALY                   | USA, MSA, and PSA   |
|                       | Stapleton, 1999      | NR                                                                            | Life-time                | Health service  | NR            | Not required               | Additional number of LY saved | USA                |
|                       |                      |                                 |                           | (UK NHS)        | 1.75%         | Not required               |                        |                     |
| Decision analytical/simulation modelling | Brown, 2014 | NR                                                                            | Until age 65             | NR             | 3.5%                  | Increase in quit attempts | USA                  |
|                       | Cantor, 2015        | Short term: quit or no-quit. Long term: alive or dead                         | 1 year or lifetime       | Health-care     | NR            | 3%                        | Quit rates             | USA and MSA          |
|                       | Croghan, 1997       | Life-time                                                                     | NR                       | NR             | 0%, 3%, 5%                             | Abstinence rates        | USA                  |

(Continues)
| Type of model          | Study                        | Characteristics                                                                 |
|------------------------|------------------------------|---------------------------------------------------------------------------------|
|                        |                              | Time-horizon | Perspective | Discounting | Analysis | Sensitivity analysis |
|                        |                              |              |             | Effects     | Costs     | Primary measure of effectiveness |                           |
| Dynamic/static modelling (n = 3) | Halpern, 2007a              | Continued cessation, relapse, resume smoking, continued smoking | 10 years | NR          | NR        | 3%          | Quit rates | NR       |
|                        | Hill, 2006                   | NR          | 6 months  | Texas government | NR        | Not required | 6 months | % individuals not smoking at 6 months | USA and MSA |
|                        | Nohlert, 2013                | NR          | Until age 85 | Societal | 3%        | 3%        | Abstinence rates | USA, MSA, and PSA |
|                        | Ong, 2005                    | NR          | 1 year | NR          | 3%        | Not required | Sustained quitters generated | MSA and PSA |
|                        | Shearer, 2006                | NR          | NR        | Government | NR        | Not required | Continuous abstinence rates | MSA |
|                        | Stapleton, 2012              | NR          | Life-time | Health service | 3.5%     | 1.5–3.5% | Abstinence rates | Various possible |
|                        | Feenstra, 2005               | NR          | 75 years | Societal | 4%        | 4%        | Abstinence rates | USA and MSA |
|                        | Ranson, 2002                 | NR          | NR        | NR          | 3.0–10.0% | 3.0–10.0% | Number of deaths averted | ECA |
|                        | Van Genugten, 2003           | Current or former smoker. Lung cancer, CHD, stroke, and COPD | Period 1998–2050 | NR | NR | NR | Total number of life-years lost as the sum of the remaining life expectancy at the age of death | MSA |
| SmokingPaST Framework (n = 1) | O’Donnell, 2011  | NR          | NR        | NR          | Not reported (n = 15), 1 (n = 3) | Health-care system/payer (n = 10) | Not reported (n = 8), 3% (n = 8) | Quit/abstinence rates (n = 13) | USA (n = 6) or combinations with USA (n = 7) |

This refers to the states considered in the model and may include: (1) never smoker, current smoker, former smoker; (2) never smoker, current smoker, ex-smoker, death; (3) current smoker, former smoker, death; (4) current smoker, recent quitter, long-term quitter; (5) no morbidity, chronic obstructive pulmonary disease (COPD) or lung cancer, coronary heart disease (CHD) or stroke first event, CHD or stroke subsequent event, death from COPD/lung cancer, death (all cause); (6) no current morbidity, asthma exacerbation, CHD or stroke; post first event, COPD or lung cancer, CHD or stroke; post subsequent event, death (CHD or stroke), death from CHD/stroke, death from COPD/lung cancer, death (all cause).

Uncertainty analysis: USA = univariate sensitivity analysis; MSA = multivariate sensitivity analysis; ECA = extreme case analysis; PSA = probabilistic sensitivity analysis; ISA = deterministic sensitivity analysis; NRT = nicotine replacement therapy; NYTCP = New York Tobacco Control Program; SES = socio-economic status; MI = minor limitations; SC = ; NR = not reported; QALY = quality adjusted life years.
The majority of the Markov models used a life-time horizon \((n = 22 \text{ of } 30)\) while decision-tree models considered a time between 1 and 50 years. Most of the studies based on other models lacked sufficient information, or reported a time-horizon of 50 years. Most evaluations used a health-care and/or payer perspective \((n = 50 \text{ of } 64)\). Twelve of 64 used a societal perspective. The reported primary measure of effectiveness in all models was quit rate or its variants (e.g. continuous abstinence rates).

The majority of the studies \((n = 55 \text{ of } 64)\) performed sensitivity analyses to account for uncertainties in their estimates. Markov model-based studies performed mainly both univariate and probabilistic sensitivity analyses. Decision-tree models used univariate sensitivity analyses often in combination with multivariate sensitivity analyses \((n = \text{five of nine})\), and the other models \((n = 25 \text{ of } 64)\) conducted univariate sensitivity analyses \((n = 13 \text{ of } 25)\).

Quality assessment and transferability

Of the 64 included studies assessed for quality, 15 were excluded based on the first criteria (no health-care perspective), 12 based on the second (no cost benefit or cost-utility analysis) and 24 on the final criteria (having major limitations). As shown in Table 3, 13 of 64 studies were then classified as having minor limitations, 35 as having potentially serious limitations and 16 as having very serious limitations.

Table 4 provides an overview of the scoring per question on the EURONHEED checklist for the 13 studies judged as having sufficient quality including the summary scores. The studies’ total scores varied between 57 and 87% and the scores of the transferability checklist from 50 to 97%.

The average score per section presented as the percentage of the total score are shown in Fig. 2. The average score per section was 0.69 \((\text{range } = 0.35–0.92)\). The sections that scored below the average (69%) were: health technology assessment study population, effectiveness, benefit measure, variability and generalizability.

**DISCUSSION**

Key findings

Markov-based state transition models with QALY as the outcome measure were the most frequently used technique in evaluating the cost-effectiveness of smoking cessation interventions. However, the majority of the studies were reported poorly, making it hard to assess their transferability using the existing checklist-based method. Where such assessment was possible, studies showed a wide variation in transferability scores, driven mainly by the method of selecting populations, assessing effectiveness and outcomes and estimating variability and generalizability of their own findings.

Relative transferability

The EURONHEED method assumes that without a quality score it would be impossible to transfer a study to another setting \([9,32,95]\). Therefore, the explicit assessment using this method resulted in some studies being more favourable candidates than others. However, on average, all studies lacked in some attributes for full transferability. One of the main differences between a high score and a low score is how differently the studies scored on the questions on costs. For example, Annemans et al. (2009), with a score of 0.50, addressed most of the cost questions only partially, whereas Hoogendoorn et al. (2008), with a score of 0.97, did so fully. Therefore, costs are important determinants of the transferability assessment \([9]\). Our review also highlighted other determinants; namely, selection of study population, intervention and comparator descriptions, effectiveness and benefit measures and variability/generalizability analyses—all scoring below the overall average score. Without a threshold, it

Table 3 Results of the quality assessment.

| Classification          | Studies                                                                 |
|-------------------------|-------------------------------------------------------------------------|
| Minor limitations       | Annemans, 2015; Annemans, 2009; Athanasakis, 2012; Bolin, 2006; Bolin, 2008; Bolin, 2009b; Boyd, 2009; Cornuz, 2003; Guerrieri, 2013; Hoogendoorn, 2008; Howard, 2008; Over, 2014; Stapleton, 1999 |
| Potentially serious     | Ahmad, 2005a; Ahmad, 2005b; Bae, 2009; Baud, 2011; Bolin, 2009a; Brown, 2014; Cantor, 2015; Chevreul, 2014; Cornuz, 2006; Feenstra, 2005; Fiscella, 1996; Halpern, 2007b; Heitjan, 2008; Hill, 2006; Hojgaard, 2011; Harley, 2008; Igarashi, 2009; Linden, 2010; Levy, 2002; Nohlert, 2013; Ong, 2005; Pinget, 2007; Shearer, 2006; Simpson, 2013; Song, 2002; Stapleton, 2012; Taylor, 2011; Tran, 2002; Van Baal, 2007; Verner, 2010a; Verner, 2010b; Von Wartburg, 2014; Warner, 1996; Welton, 2008; Xenakis, 2009 |
| Very serious limitations| Bertram, 2007; Croghan, 1997; Dino, 2008; Halpern, 2007a; Knight, 2010; Lai, 2007; Lai, 2014; Levy, 2006; McGhan, 1996; Nielsen, 2000; Olsen, 2006; Ramson, 2002; Van Genugten, 2003; Xu, 2014; Jackson, 2007; O’Donnell, 2011 |
Table 4 Results of the European Network of Health Economic Evaluation Databases (EURONHEED) checklist.

1 = yes, 0.5 = partially, 0 = no/no information, NA = not Applicable

|   | Annemans, (2015) | Annemans, (2009) | Athanasa-kis, (2012) | Bolin, (2006) | Bolin, (2008) | Bolin, (2009b) | Bovel, (2008) | Cornaz, (2003) | Guerriero, (2013) | Hoogen-doorn, (2008) | Howard, (2008) | Over, (2014) | Stapleton, (1999) |
|---|-----------------|-----------------|---------------------|--------------|--------------|--------------|--------------|--------------|----------------|------------------|----------------|----------------|----------------|
| Q1 | 1               | 1               | 1                   | 1            | 1            | 1            | 1            | 1            | 0              | 1                | 1              | 1              | 1              |
| Q2 | 0               | 1               | 1                   | 1            | 1            | 0            | 1            | 1            | 1              | 0.5              | 1              | 0              | 1              |
| HT1| 0.5             | 0               | 0.5                 | 0.5          | 1            | 0            | 1            | 1            | 1              | 0.5              | 1              | 0.5            | 0.5            |
| HT2| 0.5             | 0               | 0.5                 | 0.5          | 0.5          | 0            | 1            | 1            | 0              | 1                | 1              | 0.5            | 0.5            |
| SE1| 0.5             | 0.5             | 1                   | 1            | 1            | 0            | 1            | 1            | 1              | 0.5              | 0              | 0              | 1              |
| SE2| 0.5             | 1               | 1                   | 1            | 1            | 1            | 0.5          | 1            | 1              | 1                | 1              | 1              | 1              |
| P1 | 1               | 1               | 1                   | 1            | 1            | 1            | 1            | 1            | 1              | 0.5              | 1              | 1              | 1              |
| SP1| 1               | 1               | 1                   | 1            | 1            | 1            | 1            | 1            | 1              | 0.5              | 1              | 1              | 1              |
| SP2| 0.5             | 0.5             | 0.5                 | 1            | 1            | 1            | 0            | 0.5          | 1              | 0.5              | 1              | 1              | 0              |
| SP3| 0               | 0.5             | 0.5                 | NA           | NA           | 0.5          | NA           | 0            | 0              | 0.5              | 0.5            | NA             |
| SP4| 0               | 0               | 0                   | 1            | 1            | 0.5          | 0            | 1            | 0.5            | 1                | 0.5            | NA             |
| M1 | 0.5             | 0.5             | 0.5                 | 0.5          | 0.5          | 1            | 1            | NA           | 1              | 1                | 1              | NA             |
| M2 | 1               | 1               | 1                   | 1            | 1            | 1            | 1            | 1            | 1              | 1                | 1              | 1              | 0.5            |
| E1 | NA              | NA              | NA                  | 0.5          | 1            | 0            | NA           | 0.5          | NA             | NA              | NA             | NA             |
| E2 | NA              | NA              | NA                  | NA           | 1            | 1            | 0.5          | NA           | 0.5            | NA              | NA             | NA             |
| E3 | 0               | 0               | 0                   | 0            | 0            | 0.5          | NA           | 0            | 0              | 0                | 0              | NA             |
| E4 | NA              | NA              | NA                  | NA           | NA           | NA           | NA           | NA           | NA             | NA              | NA             | NA             |
| E5 | 1               | 0.5             | 0.5                 | 1            | 1            | 1            | 1            | 1            | 1              | 1                | 1              | 1              | 1              |
| E6 | 0               | 0               | 0                   | 0            | 0            | 0            | 0            | 0            | 0              | 0                | 0              | 0              | 1              |
| E7 | NA              | NA              | NA                  | 0.5          | 0.5          | 1            | 0            | NA           | 1              | 1                | NA             |
| B1 | 1               | 1               | 1                   | 1            | 1            | 1            | 1            | 1            | 1              | 1                | 1              | 1              | 1              |
| B2 | 0               | 0               | 0                   | 0.5          | 0.5          | 0            | 0            | NA           | 0.5            | NA              | 1              | 0              | NA             |
| B3 | 0               | 0               | 0                   | 0            | 0            | 0.5          | 0            | 0            | NA             | 0.5             | NA             |
| B4 | 0               | 0               | 0                   | NA           | NA           | NA           | NA           | NA           | NA             | NA              | NA             |
| B5 | 1               | 0.5             | 1                   | 1            | 1            | 0            | 1            | 0            | 1              | 1                | 1              | 0              | 0.5            |
| C1 | 1               | 0.5             | 0.5                 | 1            | 1            | 1            | 0.5          | 0.5          | 1              | 1                | 1              | 1              | 1              |
| C2 | 0.5             | 0.5             | 0.5                 | 1            | 1            | 0.5          | 1            | 1            | 1              | 1                | 1              | 0              | 1              |
| C3 | 1               | 1               | 1                   | 1            | 0.5          | 0            | 1            | 1            | 0.5            | 1                | 1              | 1              | 0              |
| C4 | 1               | 1               | 0.5                 | 1            | 1            | 0            | 1            | 1            | 1              | 1                | 1              | 1              | 1              |
| C5 | 0.5             | 0.5             | 1                   | 0.5          | 1            | 1            | 1            | 0.5          | 1              | 0.5             | 1              | 1              | 1              |
| C6 | 0               | 0               | 0                   | 0.5          | 1            | 1            | 1            | 0.5          | 1              | 0.5             | 1              | 1              | 0              |
| C7 | 1               | 1               | 1                   | 1            | 1            | 1            | 1            | 1            | 1              | 1                | 1              | 1              | 1              |
| C8 | 0.5             | 0.5             | 0.5                 | 0            | 1            | 1            | 1            | 1            | 1              | 1                | 1              | 1              | 1              |

(Continues)
|   | C9 | C10 | C11 | D1 | D2 | D3 | D4 | S1 | O1 |
|---|----|-----|-----|----|----|----|----|----|----|
|   | 1  | NA  | 1   | 1  | 1  | 1  | 0  | 0  | 0  |
|   | 1  | NA  | 1   | 1  | 1  | 1  | 0  | 0  | 0  |
|   | 1  | NA  | 1   | 1  | 1  | 1  | 0  | 0  | 0  |
|   | 1  | NA  | 1   | 1  | 1  | 1  | 0  | 0  | 0  |
|   | 1  | 0   | 0   | 0  | 0  | 0  | 0  | 0  | 0  |
|   | 0  | 0   | 0   | 0  | 0  | 0  | 0  | 0  | 0  |
|   | 0  | 0   | 0   | 0  | 0  | 0  | 0  | 0  | 0  |
|   | 0  | 0   | 0   | 0  | 0  | 0  | 0  | 0  | 0  |
|   | 0  | 0   | 0   | 0  | 0  | 0  | 0  | 0  | 0  |
|   | 0  | 0   | 0   | 0  | 0  | 0  | 0  | 0  | 0  |
|   | 0  | 0   | 0   | 0  | 0  | 0  | 0  | 0  | 0  |
|   | 0  | 0   | 0   | 0  | 0  | 0  | 0  | 0  | 0  |
|   | 0  | 0   | 0   | 0  | 0  | 0  | 0  | 0  | 0  |
| 1 = yes, 0.5 = partially, 0 = no/no information, NA = not applicable |

Table 4. (Continued)

Summary scores\(^a\) (%)

|   | C9 | C10 | C11 | D1 | D2 | D3 | D4 | S1 | O1 |
|---|----|-----|-----|----|----|----|----|----|----|
|   | 1  | NA  | 1   | 1  | 1  | 1  | 0  | 0  | 0  |
|   | NA | NA  | 1   | 1  | 0  | 0  | 0  | 0  | 0  |
|   | NA | NA  | 0.5 | 1  | 1  | 0  | 1  | 0  | 0  |
|   | NA | NA  | NA  | 1  | 1  | 1  | 1  | 0  | 0  |
|   | NA | NA  | NA  | 1  | 1  | 1  | 1  | 0  | 0  |
|   | NA | NA  | NA  | 1  | 1  | 1  | 1  | 0  | 0  |
|   | NA | NA  | NA  | 1  | 1  | 1  | 1  | 0  | 0  |
|   | NA | NA  | NA  | 1  | 1  | 1  | 1  | 0  | 0  |
|   | NA | NA  | NA  | 1  | 1  | 1  | 1  | 0  | 0  |
|   | NA | NA  | NA  | 1  | 1  | 1  | 1  | 0  | 0  |
|   | NA | NA  | NA  | 1  | 1  | 1  | 1  | 0  | 0  |

Full items of the EURONHEED checklist are described in Supporting information, Table S4. Items comprising the transferability subchecklist are shown in bold type. Average of the total summary score: 71%; average of the transferability summary score: 75%. \(^a\)Summary scores were calculated using the formula as in EURONHEED checklist: \(\frac{1}{n} \sum S_i \times 100\). \(^b\)Total summary score, number of questions = 42. \(^c\)Transferability summary score, number of questions = 16.
was not possible to rank the assessed studies on their relative transferability, and this will be explored further below.

**Comparison to current literature**

Several systematic reviews are available on the cost-effectiveness of smoking cessation [22–24], but only one systematic review looking at model-based economic evaluations [20]. Most of the studies included in their review used the Markov model with long-term time horizons, included comparable health states and reported the similar measures of effectiveness and outcomes as ours, and common weaknesses included poor reporting of the modelling details. However, a key difference from our review is that they did not build on their findings to evaluate the extent to which such models could be transferable from the original context to others, for wider benefits [9,10,17]. In areas outside smoking cessation, Korber has evaluated physical activity interventions for their transferability [96]. Consistent with our findings, she also found that a very few included studies explored variability from place to place and discussed caveats regarding the generalizability of results, leading to a wide variation in the transferability of the study results ranging from “low” to “very high” with everything in between [96]. Another study [97] found that population and methodological characteristics were poorly reported—a finding that echoes our own results on the weaknesses of the models.

**Implications of this review**

Despite the availability of several guidelines on how to conduct and report adequately on economic evaluations [29,31], there is still a considerable variation in the quality of published economic evaluations in smoking cessation. Arguably, this may limit the use of such evidence in other contexts. Some authors argue that the factors affecting the perception of applicability (the process question) and transferability (the outcome question) together might be broader than the factors associated with external validity [13]. Notwithstanding this difference, the EURONHEED method relies heavily upon the quality of reporting to ascertain transferability [32]. Therefore, such scores can be limited in use by the end-users for two reasons. First, a poorly constructed model could have been reported well scoring high on the transferability scale and vice versa. Secondly, without a threshold score, it is hard to judge a study or to rank and compare across the studies. Nixon et al. [32] argue that the EURONHEED score should, rather, be used as a general guide in making decisions, but also note that the explicit assessment of transferability using this method will introduce an educational element, helping researchers to improve the design, conduct and reporting of future studies.

This review highlights the educational element noted above. Transparency in the model building and subsequent analysis and results, which can be captured by the quality of reporting, can enhance our understanding of the underlying process and outcome questions. However, a robust method would require more analyses based on the model...
outputs (as opposed to the checklists), backed up by the perceptions of actual stakeholders (including decision makers) as to what is relevant, adaptable, valid and transferable to them [13,16]. The European study on Quantifying Utility of Investment in Protection from Tobacco (EQUIPT) [98] provides some promise to that end by encompassing both model-based analyses (e.g. on the parameter importance and variability) and the analysis of the stakeholder views (e.g. on the importance of interventions and intention to use economic evidence in policymaking) [99,100], in addition to the systematic reviews based on the published models such as this. Although the final results of the EQUIPT study are yet to be published, this comprehensive framework appears to provide the end-users with an understanding of a key transferability attribute—what changes in the economic model would make it transferable to their own settings and why [15].

This review also reiterates the already identified challenge in terms of the way in which economic evaluations in broader public health are designed, conducted and reported [101]. The finding that only one-fifth of the included study met quality classification for transferability implies that policymakers, researchers and journal editors need to work together in enhancing the quality of new economic evaluations and making it more transferable. The guidelines used by economic evaluation community and journals such as this are helpful to that end [102]. However, such guidelines should also emphasize the need for the authors to assess and report transferability of their models to the new contexts. This would ensure that future studies could consider adding model-based analysis of transferability on to the checklist-based evaluation, backed up by, where possible, analysis of the views of stakeholders.

Limitations

A major limitation of this review has been the limitation embedded in the existing method of transferability assessment [9,32]. Future research may overcome this limitation by adopting a comprehensive assessment as discussed above. In addition, limiting the search to English language only might have excluded some studies. However, we identified more model-based economic evaluations than a previous similar review [22]. The use of three quality criteria [31] for inclusion of studies in the transferability assessment could potentially have introduced some bias, as it was based on the overall assessment, as opposed to some standard checklists such as those by Drummond [103] or Philips [104]. However, the variety of items included in our data extraction form as outlined in the best practice guidelines [102] were very similar to the Drummond or Philips checklists, implying the possibility of such bias to be minimal. Finally, exclusion of low-/middle-income countries to reduce study heterogeneity could have limited this review in its primary focus (i.e. evidence transferability to less-affluent countries).

CONCLUSION

Existing economic evaluations in smoking cessation vary in quality, resulting mainly from the way in which they selected their populations, measured costs and effects and assessed the variability and generalizability of their own findings. All studies lacked one or more key study attributes for full transferability. A robust design, coupled with comprehensive reporting of key study attributes, could make economic evaluations transferable to a new context.

Declaration of interests

None.

Funding

S.P. and P.K.’s time in this research was funded partly by the European Union’s Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 602270 (EQUIPT).

Acknowledgements

We would like to thank Teresa Jones for facilitating searches and providing access to full text materials from the Brunel Library systems. The first version of this paper was presented to an internal seminar at the Health Economics Research Group (HERG), Brunel University London. The feedback received from HERG members is gratefully acknowledged.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher’s web-site:

Table S1 Search strategy.
Table S2 Exclusion criteria.
Table S3 List of high-income countries available at: http://data.worldbank.org/about/country-and-lending-groups
Table S4 EURONHEED checklist.