FinJeHeW Finnish Journal of eHealth and eWelfare

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Assessment of cost-effectiveness calculators for health, well-being, and safety-promoting interventions: Document analysis

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Abstract

Our objective was to identify and assess freely available web-based cost-effectiveness calculators for health, well-being, and safety-promoting interventions. Several characteristics of such calculators could enhance or hinder the use of calculators in new contexts, yet they remain insufficiently studied.

We used a qualitative document analysis method with multi-channel web search strategy which explored 2100 websites, and 5 potential calculators suggested by content experts, resulting in the inclusion of 17 calculators in our study. Data was analyzed by deductive-inductive strategy that considered their applicability and, for example, their target groups, topic fields, usability-related characteristics, and scientific evidence base. The study was conducted applying the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.

The characteristics of calculators were heterogenous, dependent on the context of their application and the target group of the calculator. Most calculators were clearly aimed at either employers, local public administrators, or policy makers. Cost-benefit analysis was the main method of analysis in 16 of the 17 calculators, and 12 of them included a comprehensive user manual. The scientific evidence base was explicated in 15 of the calculators, but the breadth of the evidence base varied widely between calculators.

A cost-effectiveness calculator's contextual and practical applicability should be analyzed in addition to its scientific evidence base when considering its implementation.

Keywords: calculator, cost effectiveness, document analysis, health, well-being, safety, internet

Introduction

With the rise of value-based social and health care practices [1], policy decision makers are increasingly expected to optimize the use of scarce public resources in a cost-efficient manner. To aid in optimization, cost-benefit or cost-effectiveness analyses are commonly used. Cost-benefit analysis evaluates the strengths and weaknesses of alternatives by comparing the expected costs and benefits [2], while cost-effectiveness analysis compares the relative costs and effects of different courses of action [3]. Investments in promoting the physical, mental, and social well-being of citizens should respond with a similar impact. Most public health interventions have been deemed cost effective [4,5], along with specific interventions targeting obesity [6] and diabetes prevention [7] as well as physical activity interventions, such as school-based interventions, interventions using pedometers, and fall-preventions programs [8]. Additionally, employer organizations provide a considerable proportion of well-being–associated activities [9]. The concept of social well-being is not strictly limited to the provision of social and health care services but can be extended to the field of social safety, and this whole complexity of policy making can be identified in terms of health, well-being, and safety promotion. Well-being policy frameworks can promote health, resilience, and overall well-being by addressing social determinants and ensuring universal access to resources [10].

Several freely available calculators have been created in recent years for promoting workplace health, public health and social safety [11]. At best, the calculators provide decision makers with an easily grasped estimate of cost-effectiveness, and they have been proposed as a viable way of disseminating research knowledge [12]. This paper defines cost-*effectiveness calculator* as any calculator, tool, framework, or index that translates a user's initial parameters into a deterministic estimate of an intervention's achieved benefits and costs.

Measuring the impact of policy intervention is a multifaceted challenge, and several factors may affect the usefulness of such calculators and the reliability of their estimates. For example, they might not be transferrable from their original context to, say, new geographical areas, or they might not consider a long time scale for the realization of costs and benefits. [13.] Impact measures that address natural units of change (as in cost-effectiveness analysis) might yield multidimensional estimates of effectiveness that are incommensurate with diverse sectors [14]. Policy decisions in the social and health care sectors are closely linked to and influenced by other public service sectors, such as actors promoting the well-being and safety of citizens, and the tools might overlook some fields of health, well-being, and safety promotion. Cost-effectiveness calculators mostly focus on evaluating individual behavior in a specific context [11] and focused on patient information sites [15,16], self-treatment tools [17] and online courses for health care professionals [18].

The aim of this document analysis is to identify and describe the freely available cost-effectiveness calculators for health, well-being, and safety-promoting interventions. The results can be used in assessing and developing cost-effectiveness calculators in future. The research questions are:

1) What is the content of the freely available calculators, including the target groups, topic areas, and usability-related issues?
2) What are the methods of analysis and evidence-base regarding cost-effectiveness?
3) What are the factors related to usability of the calculators?

Material and methods

We conducted a qualitative document analysis on freely available web-based cost-effectiveness calculators related to health, well-being, and safety promotion [19]. The method enabled a comprehensive analysis of existing calculators [20]. The study was conducted applying the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [21].

Data collection

For the data collection we applied a three-phase strategy [22]. In the first phase, we conducted customized Internet searches, using the Advanced Google engine and formulated three distinct search strings focused on the study topic and performed an iterative web search. For each query, the first 100 results were screened, yielding 300 potential documents. The search was iterative in that, after the first screening, we also screened the websites of the screened calculators to potentially find links to more calculators.

In the second phase, we conducted targeted website searches. Here, Google searches were targeted to the organizations that were relevant to our research questions and had websites in English (n=6; Figure 1), by using web-site specific Google searches. The organizations included: the US Centers for Disease Control and Prevention (CDC), the National Institute for Care Excellence (NICE) and National Health Service (NHS) of the United Kingdom, the European Commission's Community Research and Development Information Service (CORDIS), the World Health Organization (WHO), and the Organization for Economic Co-operation and Development (OECD). At each of these websites, we used three distinct search strings that included either "health promotion," "well-being promotion," or "safety promotion" combined with the exact-match term "cost effectiveness" and the search terms "tool OR instrument OR index OR matrix OR calculator OR framework." Screening the first 100 results of each search resulted in the screening of a total of 1800 documents for the study. Thirdly, the study's steering group found 5 additional calculators through consultation with content experts and via personal consultation with leading experts in research institutions.

Identification of potentially relevant documents

We selected documents based on inclusion and exclusion criteria. We included websites presenting i) freely available calculators, ii) focused on cost-effectiveness in relation to iii) health, well-being, and safety promotion at the local, regional, or national level. There had to be available iv) supplementary material and attachments belonging to the calculators, such as user manuals and background information v) in English language. *Health* was defined as health promotion and disease prevention [23], *well-being* as promotion or preservation of favorable social conditions and environments [24], and *safety* as injury prevention in everyday life [25]. We excluded websites which i) did not meet inclusion criteria, or ii) were presented for ii) commercial or iii) educational purposes.

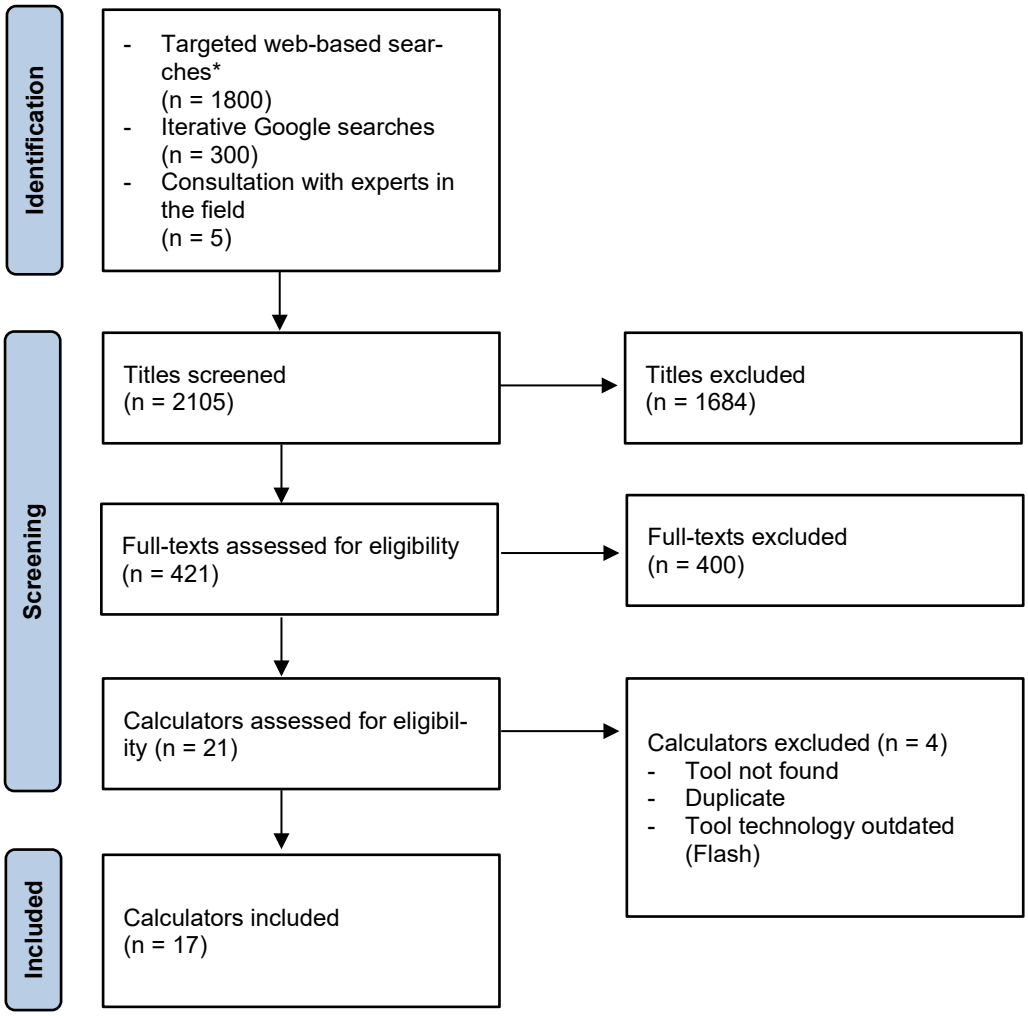
We selected documents in stages based on their titles and full available text. The title screening yielded 245 documents from targeted websites, 171 documents from Google searches and 5 from consultation with experts.

Searches of the calculators' full available documents yielded three documents from targeted websites, 15 documents from Google searches, and three from consultations (Table 1). After the removal of duplicates, 20 documents were included. In a final test of eligibility, three further items were removed from the study, as the calculators either

used outdated technology (eg, Adobe Flash software) or had been taken offline. This resulted in the inclusion of 17 calculators in our study.

Data analysis

We analyzed the documents with qualitative, inductive strategy [19]. First, we read the entire data several times to get a comprehensive overview of the content. After that, we inductively developed an analysis matrix which included information of calculators' names, developers, countries of origin, topic areas, target groups, methods of analysis, knowledge of the evidence base, supplementary material and attachments, and usability details. We piloted the matrix by extracting corresponding information from five documents into the matrix. The matrix was deemed feasible in the research group, whereupon we extracted corresponding information from all the documents to the matrix. The extracted information was then qualitatively grouped and again categorized based on similarities.



*NICE, NHS, OECD, CORDIS, CDC, WHO

Figure 1. Screening flow diagram. The figure depicts the initial number of calculators found via various search strategies as well as the decision-making phases of including/excluding calculators.

Research ethics and rigor

We conducted the study according to the ethical research guidelines [26]. Ethical review statement is not needed in this type of study [27], as the data was public. Also, rigor of the study and possible bias threats [19] were considered through to research process. An effort was made to minimize their impact with methodological precision, systematicity and transparency, and with shared and close collaboration between researchers. For example, to avoid selection bias, three researchers collaborated in selecting the documents.

Results

Most of the calculators, were developed in the US, Canada or the UK (Table 1).

Table 1. Names, countries of origin, and fields of evaluation of the identified calculators.

Calculator, country of origin	Field of evaluation
Workplace health promotion	
WellSteps ROI[1] Calculator, USA	Costs of a program; cost savings from reduced obesity and smoking
What Works Wellbeing CEA[2] Calculator, UK	Cost-effectiveness of a program
EAP[3] Workplace ROI Calculator, USA	ROI of an employee assistance program
EAP ROI Mental Health ROI Tool, UK	ROI of an employee assistance program
NSC[4] Substance Use Employer Calculator, USA	Estimated costs of a program
AHIP[5] ROI Calculator for Smoking Cessation Programs, USA	Monetary benefits of the intervention
WSPS[6] Health and Safety Calculator, Canada	Cost-savings from reduced workplace accidents
Public health and disease prevention	
Health Economic Assessment Tool (HEAT), WHO[7]	Mortality effects of increased biking
CDC[8] Diabetes Prevention Impact Toolkit, USA	Costs of diabetes prevention program; care costs of diabetes and ROI; absence from work
AMA[9] Diabetes Prevention Cost Savings Calculator, USA	Costs of diabetes prevention program; ROI
PHE[10] Weight Management Economic Assessment Tool, UK	Costs of weight reduction intervention per QALY[14]; 25-year forecast
Social and regional safety and well-being	
BHPN[11] Neighborhood Health Calculator, USA	ROI; health service use; increase in income; costs of living
LIIF[12] Societal Impact Calculator, Canada	Societal value of interventions
Online Calculator MC PICCS 3.0, USA	Costs savings from accidents and mortality prevention
Safety Causation, Benefits and Efficiency Calculator SafetyCube, EU	Costs of intervention; total benefits; cost-benefit ratio; net impact; break-even points
Social Value Calculator, UK	Monetary value and costs of various societal interventions
GMCA[13] Greater Manchester Cost Benefit Analysis Tool, UK	Cost benefit analysis of a new service

Abbreviations: [1] ROI = return on investment; [2] CEA = cost-effectiveness analysis; [3] EAP = Employee Assistance of the Pacific; [4] NSC = National Safety Council; [5] AHIP = America's Health Insurance Plans; [6] WSPS = Workplace Safety and Prevention Services; [7] WHO = World Health Organization; [8] CDC = Centers for Disease Control and Prevention; [9] AMA = American Medical Association; [10] PHE = Public Health England; [11] BHPN = Build Healthy Places Network; [12] LIIF = Low Income Investment Fund; [13] GMCA = Greater Manchester Combined Authority; [14] QALY = quality-adjusted life year

Topic area of calculators

Three main groups by topic area were discernible in the data (Table 2). Of the 17 calculators identified, seven focused on workplace health promotion (1–7 in Table 1). Four of these calculators had a general scope of workplace health and well-being (1–3, 7), and specific topic areas included mental health (4), substance abuse (5) and smoking cessation (6). Four calculators focused on public health and disease prevention (8–11), with topic areas including aged people, cycling (8), diabetes (9–10), and weight management (11). Eight calculators focused broadly on social and regional safety and well-being (12–17). These tools discussed topics linked directly to the area-level development of well-being promotion, such as increases in affordable housing (12), traffic safety (14–15), crime reduction (16) and new services (17).

Target groups of calculators

The calculators had one or more discernible target user groups, the most reported being local public administrators (8–13, 15–17) and employers (1–7, 9–10). Employers were the main target audience of all the calculators in the workplace health promotion group, and local public administration was the main target audience of both the public health and disease prevention group and the social and regional safety and well-being group. Policy makers were also mentioned as a target group of four calculators (10, 14–15, 17), three of which focused on regional safety and well-being (14–15, 17).

Analysis methods of calculators

Although we aimed at specifically "cost-effectiveness" analysis tools, among the identified calculators, 16 out of 17 estimated the monetary benefit of outcomes, or performed a cost-benefit analysis. The outcomes used in these cost-benefit or return on investment (ROI) calculators ranged from specific and straightforward outcomes (cost of sick leaves) to more complex sets of outcomes (ROI estimates for all the interventions performed in the local area at the same time as in the Greater Manchester Cost Benefit Analysis Tool). Four of the calculators gave estimates of the cost-efficiency of an intervention (including one that applied not cost-benefit analysis but only cost-efficiency analysis) (2, 9–11). Two of these calculators were concerned with the effectiveness of diabetes care (9–10). Three calculators estimated interventions' carbon emissions as their outcomes (8, 12, 16).

Table 2. Characteristics of the identified calculators.

		Calculator Topic Area and Name																	Total
		Workplace Health Promotion (n=7)							Public Health and Disease Prevention (n=4)				Social and Regional Safety and Well-Being (n=6)						
		WellSteps ROI Calculator	What Works Wellbeing CEA Calculator	EAP Workplace ROI Calculator	EAP ROI Mental Health ROI Tool	NSC Substance Use Employer Calculator	AHIP ROI Calculator for Smoking Cessation Programs	WSPS Health and Safety Calculator	WHO/Europe Health Economic Assessment Tool	CDC Diabetes Prevention Impact Toolkit	AMA Diabetes Prevention Cost Savings Calculator	PHE Weight Management Economic Assessment Tool	BHPN Neighborhood Health Calculator	LIIF Social Impact Calculator	CDC Motor Vehicle Prioritizing Interventions and Cost Calculator for States 3.0	Safety Causation, Benefits, and Efficiency Calculator	Social Value Calculator	GMCA Greater Manchester Cost Benefit Analysis Tool	
Target groups	**For local public administration**								X	X	X	X	X	X		X	X	X	9
	For employers	X	X	X	X	X	X	X		X	X								9
	For policy makers										X				X	X		X	4
Analysis methods	**Cost-benefit analysis (or ROI)**	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	16
	Cost-effectiveness analysis (incl. CUA)		X							X	X	X							4
	Carbon reduction considered in the analysis								X				X				X		3
Usability	**Web-based interface**	X		X	X	X	X	X	X	X	X			X	X	X			12
	Freely available; no registration	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	16
	Comprehensive user manual		X			X	X		X	X		X	X	X	X	X		X	11
	Privacy statement included			X	X	X	X			X									5
	Secondary use of data mentioned						X			X									2
Evidence base	**Scientific evidence of effectiveness presented**	X	X	X		X	X		X	X	X	X	X	X	X	X	X	X	15
	National or regional statistics applied (or user can customize based on provided national or regional estimates)					X	X			X		X			X	X	X	X	8

Abbreviations: ROI = return on investment; CEA = cost-effectiveness analysis; CUA = cost-utility analysis; EAP = Employee Assistance of the Pacific; NSC = National Safety Council; AHIP = America's Health Insurance Plans; WSPS = Workplace Safety and Prevention Services; WHO = World Health Organization; CDC = Centers for Disease Control and Prevention; AMA = American Medical Association; PHE = Public Health England; BHPN = Build Healthy Places Network; LIIF = Low Income Investment Fund; GMCA = Greater Manchester Combined Authority

Usability of calculators

Regarding usability, twelve calculators were fully available for use with an internet browser (1, 2–10, 13–15), while, on further inspection, five calculators used a Microsoft Excel–based external program that required downloading the Excel macro spreadsheet application file (2, 11–12, 16–17). These calculators typically had more complicated structures and included a broad set of parameters on several worksheets. All the calculators were free to use, and 16 did not require any user registration (registration in 5). All but six calculators included a comprehensive user manual on their websites (1, 3–4, 7, 10, 16). Most of these manuals were thorough handbooks of up to 80 pages and provided comprehensive information on the calculator's goals and the evidence used to evaluate its parameters, but some user guides were relatively limited and did not, for example, explain the methods used by the calculator. Five of the calculators or calculator web pages included a privacy statement (3–6, 9). Of the 17 calculators, two mentioned the secondary use of the data (6, 9). One calculator web page clearly stated that the user data would not be involved in secondary use (5). One calculator had an ambiguous statement that user data might be employed for further analyses, and some calculators had an opt-out policy that allowed users to decide whether the data could be used for secondary purposes (1).

Evidence-base of calculators

The evidence base declared in the calculators varied. Some calculators did not report any evidence base for their analyses (13), some used a small number of studies as their evidence base (16), and some had performed a comprehensive review of the current scientific literature for all the estimated parameters (8–9, 14). In four calculators, scientific evidence was used only in devising the analysis methods, and the user provided all the empirical estimates of program effectiveness (5). Fifteen calculators used either scientific studies or governmental and expert reports in their evidence base. Two calculators did not report how the evidence for parameter estimates was gathered (4, 7). Eight calculators specifically allowed users to customize or localize their estimates based on national or regional statistics of, for example, various European countries or states of the United States (5–6, 9, 11, 14–17).

Discussion

Based on our results, the freely available web-based health, well-being, and safety-promotion cost-effectiveness calculators varied widely. The topic fields of the calculators fell into three distinct groups, including workplace health promotion, public health and disease prevention, and social and regional safety and well-being. It is quite reasonable that calculators in these fields are separate from one another, as the operating logic and actors differ between them; workplace health promotion is inevitably linked to the organizational context and goals of companies [28], whereas public health and disease prevention interventions have (partly without intent) been linked to distinct clinical specialties [29,30], while social and regional development is performed by local and regional public authorities (with a recent emphasis on the importance of the "health in all policies" approach) [31]. The calculators targeted three distinct audiences: employers, local public administrators, and policy makers in general. The role of local public administrators was quite naturally accentuated over that of policy makers, as most of the calculators were framed as tools for evaluating the feasibility of implementing an intervention. Although the calculators targeted to employers seemed straightforward, they might at best convince employers of the

cost-effectiveness of workplace health promotion programs. Local- and regional-level calculators appeared complicated, and their use might require additional resources that would ultimately hinder their applicability.

Several of the calculators focused on cost-benefit analysis and measured only the financial ROI of the intervention. ROI analysis is a straightforward approach that is usually applicable in contexts where outcome estimates are easily measurable (e.g. absent vs. capable of working) and less suitable for situations in which outcomes and their monetary value are more ambiguously constructed. ROI estimates were especially prominent in calculators targeted at employers, which is logical, as their role in the occupational health care system is typically that of a payer. Focusing merely on financial estimates may seem reductionistic, as it might easily fail to account for the spillover effects of improvements in health status and consider only the direct costs and benefits of an intervention [32]. Estimation of effectiveness is complex and uncertain; indeed, some of the calculators might offer an unnecessarily simplistic view of cost-effectiveness estimation by expecting the user to be capable of estimating these figures. One should also bear in mind that the results of economic evaluation should not be the only means of evaluating an intervention. As the implementation of health interventions is typically complex, other means of evaluation should also be used that consider factors such as equality impact. Some calculators expected users to have information on both the cost side of their interventions and on the effectiveness of the intervention. It is true that an ROI estimate for an intervention can be created with the inclusion of these 2 parameters, but this might unnecessarily burden the user with obtaining a clear estimate of effectiveness.

The usability-related characteristics of the calculators varied. The Excel-based calculators were clearly intended for more complicated analysis than the more simplistic web-based calculators. Excel-based calculators particularly benefit users who need to save the estimated parameters for further use. Almost all the calculators included a comprehensive user manual that provided information on the background work and scientific evidence used in creating them. In the case of some calculators, finding the user manual required additional work. We recommend including a clear background information sheet or manual in the vicinity of the calculator. Privacy issues and information on the secondary use of user data should be clearly communicated [33], but the identified calculators only partially met this standard.

Even when the methods used to create the calculator estimates are simplistic, the scientific evidence base of the calculators should be clearly communicated, making it easier to evaluate the calculator's suitability and transferability to different contexts of application. Some of the calculators allowed customizing the analysis parameters for a specific country or state. This approach particularly supported the localization of results for a specific context and clearly communicated that the calculator was specifically designed for this context of use. Making the calculator customizable is strongly recommended for interventions that are known to be highly context dependent, such as public health interventions [34,35].

Some common features might limit the applicability of these calculators. The identified calculators were diverse in their fields of application, target groups, and employed methods, which might reduce the likelihood of finding a proper calculator for a specific problem via an uninformed web search. It should be noted that the calculators rarely

welcomed any but a highly positivistic and rationalistic approach for using them. In addition, evidence-based policies might not be applied due to issues overlooked by these calculators, for example, the complexity of political processes, decision makers' low awareness of research findings, and inadequate communication between researchers and policy makers [36,37]. Other reasons hindering the policies' application include a lack of resources for performing program evaluations [38] as well as research findings not being locally relevant or applicable [36]. These issues could be addressed in the creation of calculators by drafting potential roadmaps of implementation for the evidence-based policies related to the calculators and including these in the calculators' manuals. Other proposed solutions for these problems include high-quality information bases for decisions, the availability of professionals with data analysis and policy evaluation skills, and incentives to proceed toward evidence-based practices [39].

The diversity of the calculators' characteristics suggests that there may be no commonly shared standards of what constitutes a good-quality calculator. Guidelines with shared standards have been applied, at a more general level, to health technology assessment, in which interventions are typically expected to meet criteria of efficacy (or effectiveness), cost-effectiveness, safety, and budget impact [40]. However, our analysis implied that one of the key dimensions to assess would be the organizational fit between the calculator and the implementing organization. Adopting similar frameworks of quality criteria for online tools, including their evidence bases and their organizational fit, could lessen their heterogeneity.

Discussion of methods and limitations

This document analysis conducted a gray literature search strategy to identify relevant freely available web-based calculators [22,41]. In the process, we considered including more than the first 100 results of a Google search, and we conducted some test queries in which we planned to analyze the first 300 search results. However, it soon became apparent that a non-focused web search on a professional topic (such as evaluation of cost-effectiveness) is likely to return much context-irrelevant content, including spam. Additionally, potential computer security threats related to the non-focused web search should be acknowledged, as a sizable portion of even the first 300 query results appeared to be spam sites. In addition, limiting to English language only may have excluded some relevant documents but also diminished bias of selected other languages.

Because Google searches are inevitably incomprehensive, our web-based search strategy may not have found all the relevant calculators on the internet. To avoid selection bias in choosing the documents (calculators) [20], we employed pre-defined inclusion and exclusion criteria, and three researchers collaborated in selecting the documents. Additionally, using separate search branches improved the comprehensiveness of our findings, as unique calculators were found via each branch.

Conclusions

The methods of analysis, scientific evidence bases, and usability of the identified cost-effectiveness evaluation calculators varied widely. Findings suggest using clear reporting practices, such as comprehensive user handbooks, and capability to change calculators' model parameters to fit the implementing organizations' characteristics, to facilitate the swift assessment of a calculator's applicability and enabling the customization of the calculator for specific contexts of use. When considering the implementation of a cost-effectiveness

calculator, its contextual and practical applicability and its scientific evidence base should both be analyzed.

Conflicts of interest

The authors report no conflicts of interest.

Acknowledgments

We wish to thank the steering group of this study for valuable help in recruiting experts in the field during the data collection phase.

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