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ECONOMIC EVALUATION OF POISON CENTERS: A SYSTEMATIC REVIEW

Tais F. Galvao
University of Brasilia and Federal University of Amazonas
email: taisgalvao@gmail.com

Everton N. Silva
University of Brasilia

Marcus T. Silva
University of Brasilia and Ministry of Health of Brazil

Alvin C. Bronstein
Denver Health and Hospital Authority and University of Colorado Health Sciences Center

Mauricio G. Pereira
University of Brasilia

Objectives: The aim of this study was to summarize and assess economic evaluations of poison centers (PCs) from the perspectives of society, the payer, and the healthcare system.
Methods: A systematic review was performed to identify complete economic evaluations regardless of the language or publication status. Two reviewers evaluated the abstracts for eligibility, extracted the data, and assessed the study quality using a standardized tool.
Results: In total, 422 non-duplicated studies were retrieved, but only nine met the eligibility criteria. Five of the eligible studies were published in the 1990s, and four were published in the 2000s. Six studies met at least seven of ten quality criteria. In all studies, the presence of PCs was compared with a scenario of their absence. Eight studies used cost–benefit analyses and one used a cost-effectiveness approach. The cost–benefit ratios ranged from 0.76 to 7.67, which indicates that each United States dollar (USD) spent on poison centers can save almost 8 USD on medical spending. A cost-effectiveness analysis showed that each successful outcome achieved by a PC avoids a minimum of 12,000 USD to 56,000 USD in other healthcare spending.
Conclusions: The data in our review show that PCs are economically viable. PCs improve the efficiency of healthcare expenditure and contribute to the sustainability of the healthcare system. An investment in PCs is a rational public health policy approach that contrasts the current trend of reducing spending on PCs.

Keywords: Poison control centers, Systematic review, Economic evaluation, Cost–benefit analysis, Cost-effectiveness analysis

Poison centers (PCs) assist poisoned individuals by providing the best available management by phone or even delivering emergency treatment in some cases. These centers have provided their services to public and healthcare professionals for more than 50 years (20). Although PCs most commonly respond to inquiries regarding patients under the age of 5 that have typically been exposed to the poisonous agent at home (7), they also help to identify public health outbreaks, respond to terrorism, and provide public awareness during chemical catastrophes (29).

Despite the benefits of PCs, they have historically lacked stable financing and have been highly sensitive to healthcare expenditure reductions. Some PCs in the United States (U.S.) have been closed because of budget cuts, since the 2008 financial crisis (7;11;30;35).

Economic evaluations are important tools to help allocate health resources efficiently in the context of resource competition and can identify the benefits and costs with comparative analyses of the intervention options (9;12;19;22). Systematic reviews of economic evaluations summarize high-quality studies and provide support to decision makers in an efficient allocation of healthcare resources.

Systematic reviews of economic evaluations of PCs are not available to our knowledge. Therefore, our objective was to summarize and assess the economic evaluation of PCs from the perspectives of society, the payer and the healthcare system to consequently inform decision makers of the economic viability of PCs.

METHODS

Study Eligibility Criteria

Economic evaluation studies that compared PCs with an alternative intervention from the perspectives of society, the payer, and the healthcare system were eligible for this review. The outcomes of interest were economic evaluations results (cost–benefit ratios, incremental cost-effectiveness ratios, incremental cost–utility ratios, and incremental costs).

Search Strategy and Study Data Sources

A literature search was conducted in June 2010 with no language or publication date restrictions, and the search was updated monthly until November 2011. We searched MEDLINE, Embase, Scopus, Centre for Reviews and Dissemination databases (CRD, including the NHS EED, HTA, and DARE databases), the Cochrane Library, the Cochrane Central Register of Controlled Trials (CENTRAL), mCRT (metaRegister of Current Controlled Trials), Latin American and Caribbean Center on Health Sciences Information (LILACS), and Scientific Electronic Library Online (SciELO) databases. We also screened peer-reviewed, published abstracts from the proceedings of the North American Congress of Clinical Toxicology (NACCT), the

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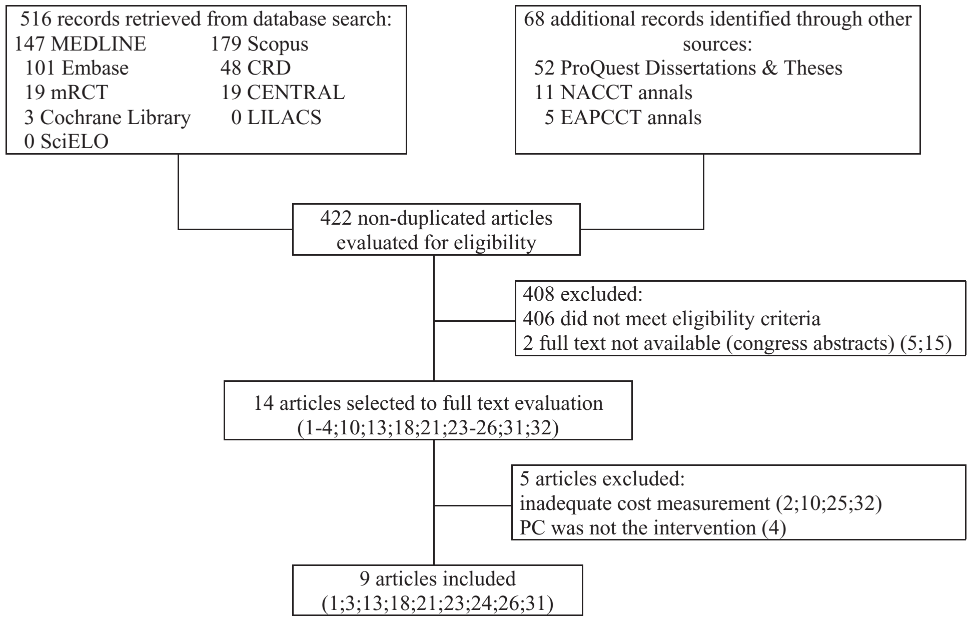

Figure 1. Flowchart depicting the search, selection, and inclusion of studies.

International Congress of the European Association of Poisons Centers and Clinical Toxicologists Congress (EAPCCT), and ProQuest Dissertations & Theses. This gray literature search was performed to minimize the risk of publication bias and to identify relevant studies that were not published in indexed periodicals.

The search strategy used for MEDLINE (*via* PubMed) was: ("poison control centers"[mesh] or "poison control centers"[tw] or "poison control center"[tw] or "poison control centre"[tw] or "poison information centre"[tw] or "toxicology center"[tw] or "toxicology centre"[tw] or "poison center"[tw] or "poison centre"[tw] or "poison information centre"[tw] or "poison information services"[tw] or "poisons information services"[tw]) and (cost and (cost or effectiveness or utility or benefit or minimization or consequence) or economic evaluation or health economics or health technology assessment). For the other databases we adapted this search strategy.

Study Selection and Data Extraction

Two reviewers, a pharmacist with clinical toxicology expertise (TFG) and a PhD economist experienced in health economic evaluation (ENS), selected the articles independently after reading their titles and abstracts.

One reviewer assembled the study data of interest from each publication in an online spreadsheet, and the other reviewer checked the information. We collected from studies the country and year in which the cost data were collected, type of economic evaluation, time horizon, perspective, population, intervention, alternative intervention, discount rate, sensitivity analysis, scenarios adopted, costs measured, effectiveness considered, and economic results. For papers that any of these data were missing, we attempted to contact the corresponding author to obtain the needed information.

Quality and Risk of Bias Assessment

We used the Drummond ten-item checklist (9) to determine whether the method used in each study was adequate for the proposed objectives and whether the results were valid. These parameters were considered when interpreting the evidence retrieved.

Data Analysis

The quantitative data were extracted as it was presented in the articles. We did not adjust or summarize the original data to avoid a potential introduction of bias. However, when the cost-benefit ratio was not available, we calculated the ratio of the benefits (extra charge to the health system) to the operational cost of the PC, based on the information available in the articles.

RESULTS

In total, 422 non-duplicated publications were found, and nine met the inclusion criteria (Figure 1). We excluded two eligible studies published in congress abstracts because additional information needed for inclusion could not obtained after contacting the authors (5;15). The results of these studies were favorable to PCs, and thus risk of publication bias is not denoted.

Three economic evaluations did not meet at least seven of the ten quality evaluation items (1;21;26) (Supplementary Table, which can be viewed online at www.journals.cambridge.org/thc2012012). Five studies failed in their allowance for uncertainty, as sensitivity analysis was not reported (1;18;21;26;31). Four did not adequately describe the PC operating costs and consequences (1;13;21;26). Six studies

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Table 1. Characteristics of the Studies Included

Study	Country	Cost year	Currency	Type of economic evaluation	Perspective	Target population
Kearney 1995 (18)	US	1991	USD	CBA*	Society†	Asymptomatic children and adults, managed at home
Harrison 1996 (13)	US	1994	USD	CEA	Society	Asymptomatic or symptomatic children and adults, managed at home or at a healthcare facility
Miller 1997 (23)	US	1992	USD	CBA	Payer	Asymptomatic or symptomatic children and adults, managed at a healthcare facility
Phillips 1998 (24)	US	1994	USD	CBA	Society and payer	Asymptomatic or symptomatic children without access to PC, managed at home or at a healthcare facility
Anell 2001 (1)	Sweden	1999	SEK	CBA*	Healthcare system*	Asymptomatic or symptomatic children and adults, managed at home or at a healthcare facility
Blizzard 2008 (3)	US	2004	USD	CBA	Payer	Asymptomatic children and adults, managed at home
LoVecchio 2008 (21)	US	2008	USD	CBA*	Healthcare system*	Asymptomatic children and adults, managed at home
Toverud 2009 (31)	Norway	2004	USD	CBA	Healthcare system	Asymptomatic or symptomatic children and adults, managed at home or at a healthcare facility
Ponampalam 2010 (26)	Singapore	2004, 2005	SGD	CBA	Society*	Asymptomatic or symptomatic children and adults, managed at home or at a healthcare facility

Note. *Information inferred by the reviewers; †Information obtained by contacting the study corresponding author.
US, United States; USD, United States dollar; SEK, Swedish krona; SGD, Singapore dollar; CBA, cost–benefit analysis; CEA, cost-effectiveness analysis.

did not report the time horizon, which made it impossible to determine whether the discount rate used was appropriate (1;3;21;24;26;31). One fundamental piece of information missing in three studies (1;18;21) was the type of economic evaluation, which the reviewers had to assume from the available information (Table 1).

The studies similarly described the infrastructure and operation of the poison centers. PCs were characterized as offering only telephonic 24-hour assistance by healthcare professionals, including physicians, nurses or pharmacists with specialized training in toxicology, and access to computerized resources to support the calls. No included studies assessed PCs with emergency poison treatment facilities.

The residents of the centers' geographical service area were the target population of each center and included individuals of all ages who had used the service previously or were likely to use it. Three studies surveyed healthcare personnel to obtain economic evaluation data (1;26;31).

All economic evaluations were undertaken in developed countries, mainly the United States ($n = 6$, four in the 1990s and two in the 2000s). The other studies were from Sweden (1), Singapore (26), and Norway (31), all in the 2000s. Eight studies used cost–benefit analyses, and one used a cost-effectiveness evaluation (13). The perspectives adopted in the studies were from the society (13;18;24;26), the healthcare system (1;21;31), and the payer (3;23;24). All included studies examined a time horizon of less than 1 year. If the time horizon was not available in the reports, we obtained this information by contacting the authors (18;23;31) or conservatively assumed that the time horizon was less than 1 year (8;14–16;28;33), if the authors could not be contacted.

Two studies restricted their direct costs to medical care, including hospitalizations and medical consultations (13;26). The majority of studies considered non-medical direct costs, such as ambulance/emergency medical services, other healthcare provider services and the hours spent by healthcare professionals researching the information to manage the poisoning (1;3;18;23;24;31). Only two studies included indirect costs related to the target population's time away from gainful employment and earnings lost due to death (23;26).

Costs were calculated based on the average treatment charges from hospitals or health departments. The cost savings were assessed by considering a scenario in which the PC was absent. The treatment cost of a poison exposure was estimated *via* telephone surveys of individuals who used PC services (1;3;18;21;31), expert panel (13), literature review (23), or author inferences (26). One research used data from a real situation in which calls to the PC were rerouted to 911 emergency operators (24).

Outcomes from cost–benefit analysis were measured in monetary terms, by quantifying the extra cost that would be incurred without PCs. This extra cost represented the unnecessary costs of medical consultations, emergency department visits, and inpatient hospitalizations that would most likely not have occurred if a PC were available. The results of each study are presented in Table 2.

Table 2. Economic Results of Included Studies: Comparison of Presence Versus Absence of Poison Centers

Study	Costs considered	Benefit or effectiveness	Outcome	Study conclusion	Sensitivity analysis and adopted scenarios
Kearney 1995 (18)	Direct	Extra cost from PC absence	CBR = 5.30*	Each 1.00 USD invested in a PC saves 3.50 USD in healthcare expenses from the societal perspective	Not conducted
Harrison 1996 (13)	Direct	Morbidity and mortality	ICER = −12,000.00 USD (morbidity), −56,000.00 USD (mortality)	Each additional successful outcome achieved with a PC saved at least 12,000 USD in cases of morbidity 56,000 USD in cases of death in healthcare expenses from the societal perspective	Two-way analysis: no qualitative change in results, even when costs were changed and no difference in effectiveness between the groups was assumed
Miller 1997 (23)	Direct and indirect	Extra cost from PC absence	CBR = 6.5	Each 1.00 USD invested in a PC saved 6.50 USD in health expenses the perspective of the payer	One-way analysis: no qualitative change in results, even with a benefit change of ± 25%
Phillips 1998 (24)	Direct	Extra cost from PC absence	CBR = 2.03 (society)* 6.18 (payer)*	Each 1.00 USD invested in a PC saved 2.03 USD in health expenses from societal perspective and 6.18 USD from the perspective of the payer	Multivariate analysis: no qualitative change in results, even when the costs and probabilities for PC consulting were changed, and assuming wrong classification place of treatment appropriateness.
Anell 2001 (1)	Direct	Extra cost from PC absence	CBR = 1.05*	Each 1.00 SEK invested in a PC saved 1.05 SEK in healthcare expenses from the perspective of the healthcare system	Not conducted
Blizzard 2008 (3)	Direct	Extra cost from PC absence	CBR = 7.67	Each 1.00 USD invested in a PC saved 7.67 USD in healthcare expenses from the perspective of the payer	One-way analysis: no qualitative change in the results, even with change in emergency department visits and ambulance services costs, and the probability of calling for ambulance
LoVecchio 2008 (21)	Direct	Extra cost from PC absence	CBR = 36.00†	Each 1.00 USD invested by the state in a PC saved 36 USD in healthcare expenses from the perspective of the healthcare system	Not conducted
Toverud 2009 (31)	Direct	Extra cost from PC absence	CBR = 0.76*	Each 1.00 USD invested in a PC saved 0.76 USD in healthcare expenses from the perspective of healthcare system	Not conducted
Ponampalam 2010 (26)	Direct and indirect	Extra cost from PC absence	CBR = 2.76*	Each 1.00 SGD invested in a PC saved 2.76 SGD in healthcare expenses from the societal perspective	Not conducted

Note. *Cost–benefit relationships calculated by reviewers based on study data. †Only the expenditure of the state government was considered, not the total annual budget.
USD, United States dollar; SEK, Swedish krona; SGD, Singapore dollar; ICER, incremental cost-effectiveness ratio; CBR, cost–benefit ratio.

Studies from the United States showed the greatest savings, with cost–benefit ratios ranging from 2.03 to 7.67 (3;24); that is, for each United States dollar (USD) spent on the PC, up to 7.67 (USD) in healthcare costs were saved. In other countries, this ratio ranged from 0.76 to 2.76 (26;31). One study found that the overall satisfaction with the service approached 100 percent, but this finding was not incorporated into the cost–benefit analysis (31).

In one study, the cost–benefit ratio only considered state funding, which showed a saving of 36.00 USD for each dollar invested in the PC by the state (21). Because U.S. centers have complex financing that includes federal, state, and local funding along with grants and donations (16), this result probably overestimates the potential benefits of the PC. As our attempt to contact the study's authors failed, we decided to classify this study as an outlier and considered the results unclear.

The cost-effectiveness study assessed exposures to four different poisons in adults and children: acetaminophen, tricyclic antidepressants, household cleaning substances, and cough and cold medications (13). In all cases, morbidity and mortality were the outcome. The results showed minimum incremental cost-effectiveness ratios of −12,000 USD for morbidity and −56,000 USD for mortality, which shows that the PCs saved a minimum of 12,000 USD to 56,000 USD for each case of poisoning successfully handed.

Qualitatively, the results were supported by studies that performed sensitivity analyses, which showed robust PC resource savings (3;13;23;24).

DISCUSSION

The evidence from the included economic evaluations favor PCs regardless of the perspective adopted. In the cost–benefit analyses, the savings from the PCs clearly offset the operating expenses from the perspectives of society, payer, and healthcare system. From the societal perspective, the cost-effectiveness evaluation found negative incremental cost-effectiveness ratios (i.e., an increase in effectiveness led to a reduction in costs). Incremental cost-effectiveness ratios that result in savings are seldom obtained in cost-effectiveness studies. Considering the thresholds for cost-effectiveness currently in use, PCs appear to be highly cost-effective (33). Although PCs indicate promising economic results, experience has shown that this is an extremely difficult concept for health insurance providers and governmental funding agencies to understand, and they often choose not to invest in such health technologies despite the cost advantages.

Strengths and Limitations of the Present Review

The review was conducted according to the current systematic review quality standards, including the sensible search in the main literature databases, the selection process that was conducted independently by specialists and the cross-checked data abstraction (8;14). We attempted to provide a detailed description of our method to enable its reproducibility.

We sought to minimize the effect of publication bias by not restricting our search to any particular language or any publication date range and by including gray literature search. These procedures are important because of the negative impact of publication bias on systematic review results (28). The two congress abstracts that were excluded due to lack of important information would probably not alter our findings nor suggest in a risk of publication bias, as their results showed benefits from PCs (5;15).

The quantitative results from the included studies were not adjusted for inflation or converted into an unique reference currency because there is no consensus on international economic evaluation guidelines (8;17). Moreover, because of the heterogeneity of the healthcare systems involved, especially regarding their financing and costs, comparative analyses of absolute monetary values are not recommended. The same cannot be said of the studies' qualitative results, which may indicate the most cost-effective strategy for a specific context. For an intervention that generates resource savings, it is relatively more important to understand the ratio of savings to costs than the absolute value of the savings.

Limitations of the Included Economic Evaluations

Economic evaluation tools for health technologies were developed in the 1960s, and these methods have been used mostly to compare medicines rather than programs (9). The scarcity of studies addressing programs may be reflected in the methodological limitations observed in several of the included articles.

Included studies analyses lacked specific definitions of the type of economic evaluation used, which can lead to challenges in interpretation. Additionally, the time horizon was often undefined, which can hinder the discount rate assessment and the determination of whether the timing of the study was adequate (9). The description of the study perspective was often insufficient, which makes it impossible to verify whether the cost quantification was appropriate (9). Few studies included sensitivity analyses, which are an important feature of economic evaluations because they determine the impact of the changes in the model parameters on the study results (6;27).

All of the included economic evaluations assessed PCs that provided only telephonic information for the public or healthcare professionals and were conducted in four different high-income economies (36), which may limit the applicability of these results to PCs of distinct structure and to countries with lower economic levels. The highest PC cost–benefit ratios in this review were from the United States, which has one of the greater proportions of healthcare spending relative to its gross domestic product (15.7 percent) (34). Another limitation of the generalization of these results is that most of these studies were conducted in the 1990s. This concern may be assuaged by the similar or better results of more recent studies. For example, an update of one study included in our review (23) found that the cost–benefit ratio had risen from 6.5 to 13, which was a twofold increase from the ratio measured 10 years before (15).

The quality of our review depends on the quality of the primary studies. These studies obtained data from sources that were not particularly robust, including inferences, expert panels, and non-random telephone surveys, which may have weakened the results.

Despite these limitations, all of the included studies appear to support PCs as a rational strategy to increase healthcare efficiency by providing health benefits and saving money. PCs provide positive and cost-saving effects to the health sector in all available perspectives, including the societal, that comprises a broader range of benefits.

Our results could be considered conservative as the included studies did not incorporate important intangible costs, such as patient and family anxiety or lost wages from poisoning treatment. Additionally, some studies only comprised unintentional exposures that were not life-threatening. Including more severely poisoned patients in the analytical model might further prove the ability of PCs to mitigate greater costs.

CONCLUSIONS

Poison centers are economically viable and have highly favorable incremental cost-effectiveness and cost–benefit ratios from the perspective of the society, the healthcare system, and the payer. The savings offered by PCs offset their operational costs. Investing in existing PCs and opening new PCs to assist neglected populations is a rational strategy, in direct contrast to the current trend of resource reduction for PCs. Future research should analyze the intangible costs of poisoning, evaluate the impact of PCs on more severely poisoned patients and assess this health technology in less developed countries.

SUPPLEMENTARY MATERIAL

Supplementary Table 1
www.journals.cambridge.org/thc2012012

CONTACT INFORMATION

Tais F. Galvo, MSc, Doctorate student, Faculty of Health Sciences, University of Brasilia, Brasilia, Brazil; Pharmacist, Amazonas Poison Control Center, Getulio Vargas University Hospital, Federal University of Amazonas, Manaus, Amazonas, Brazil
Everton N. de Silva, MSc, PhD, Professor, Faculty of Ceilandia, University of Brasilia, Brasilia, Brazil
Marcus T. Silva, MSc, Specialized Technician, Department of Science and Technology, Ministry of Health of Brazil; doctorate student, Faculty of Health Sciences, University of Brasilia, Brasilia, Brazil
Alvin C. Bronstein, MD, FACEP, Medical Director, Rocky Montain Poison Center, Denver Health and Hospital Authority; Associate Professor, Department of Emergency Medicine, University of Colorado Health Sciences Center, Denver, Colorado
Mauricio G. Pereira, MD, MPH, PhD, Professor, Faculty of Medicine, University of Brasilia, Brasilia, Brazil

CONFLICTS OF INTEREST

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