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COST AND ECONOMIC BENEFIT OF CLINICAL DECISION SUPPORT SYSTEMS FOR CARDIOVASCULAR DISEASE PREVENTION: COMMUNITY GUIDE SYSTEMATIC REVIEW

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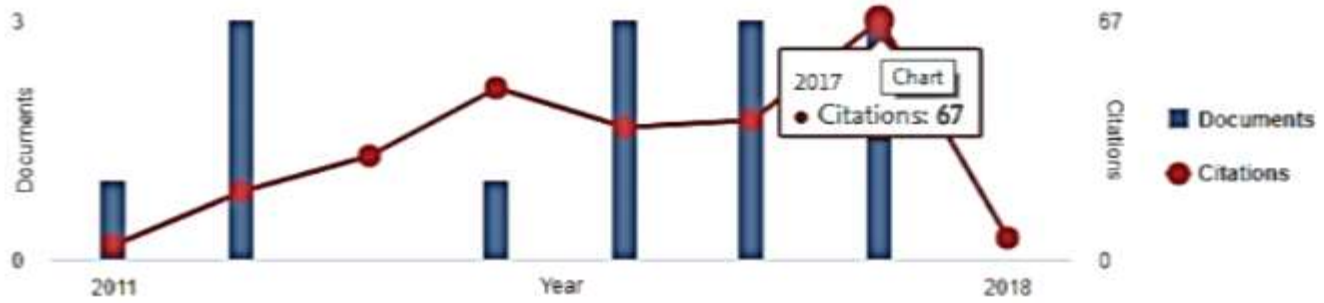

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INTRODUCTION

- American Heart Association estimated that the annual cost of
- cardiovascular disease (CVD) and stroke in 2011–2012 was $193.1 billion in medical care
- $123 billion in lost productivity from premature death

INTRODUCTION

- A substantial part of this burden is avoidable by preventing and controlling major risk factors for CVD, including hypertension, hypercholesterolemia ,and diabetes.
- Clinical decision support systems (CDSSs) are computer-based tools used to assist health providers in preventing and controlling these risk factors.
- The evidence showed that CDSSs improved screening for CVD risk factors and improved practices for CVD-related preventive care services, clinical tests, and treatments.

INTRODUCTION

- The objective of the present study is to assess the economic value of CDSS interventions for CVD prevention based on a systematic review of the literature.

METHOD & MATERIAL

- Briefly, Community Guide systematic economic reviews have the multiple objectives of:
- providing evidence-based estimates of what it costs to implement an intervention.
- calculating the expected benefits from averted health care costs and worksite productivity losses due to reduced morbidity and mortality,
- making a judgment of economic value based on estimated cost-benefit or cost-effectiveness.

METHOD & MATERIAL

- CDSSs for CVD prevention were defined as computer-based information systems designed to assist health care providers in primary, secondary, and tertiary care settings implement guidelines and evidence-based practices by providing.
- tailored reminders to conduct or schedule preventive and screening services.

METHOD & MATERIAL

- The CDSS interface with the provider occurs at the point of care, based on individual patient data,
- and assists providers with preventive care, and treatment of recommendations for screening, of patients who have risk factors for CVD such as obesity, inactivity, smoking, hypertension, hyperlipidemia, or diabetes.
- Improved clinician action should mitigate the risk factors and ultimately lead to reduced morbidity and mortality from CVD, thereby also improving economic outcomes

SEARCH STRATEGY & INCLUSION CRITERIA

- The studies for this systematic economic review were drawn from the results of 3 searches:
- The primary source was the set of studies referenced in a broad systematic review published in 2012.
- Period: January 1975 to January 2011
- Databases : PubMed, CINAHL, PsycINFO, PubMed NLM, and Web of Science
- Scope: CDSS in all health topics

SEARCH STRATEGY & INCLUSION CRITERIA

- The Bright et al. search was updated to cover more recent studies.
- Period: January 2011 to October 2015
- Databases : PubMed, CINAHL, PsycINFO, PubMed NLM, and Web of Science
- Scope: CDSS in CVD prevention
- A search was conducted within economics-related databases using the strategy implemented in Bright et al.
- Period: January 1970 to October 2015
- Databases: JSTOR, EconLit, Centre for Reviews and Dissemination
- Scope: CDSS in CVD prevention

SEARCH STRATEGY & INCLUSION CRITERIA

- Studies were included in this review if they:

1. met the intervention definition,
2. were in English,
3. were implemented in a high-income economy, and reported one or more of:
4. the cost of intervention, change in health care cost, change in productivity, other economic benefit, cost-benefit, or cost-effectiveness

INTERVENTION COST

- The cost to develop a CDSS is the cost of compiling evidence-based narrative guidelines and programming the guidelines and decisions into code to produce prompts for provider action.
- The day-to-day use and maintenance of the CDSS require staff time and other resources, and are categorized under operating cost.
- In summary, the components of capital cost are development and implementation and the components of operating cost are maintenance and operation

INTERVENTION COST

Annualized intervention cost was estimated by distributing the one-time cost of development and implementation equally over the assumed 5-year life of the system and adding this annual amortized cost, discounted at 3%, to the annual cost of operation.

A CDSS can be embedded within an electronic health record (EHR) system containing patient demographics and all health-related data, or it can be built on a registry that contains information only for patients with a specific disease or condition

INTERVENTION COST

- The cost of collecting and populating the database with patient information, whether for an EHR or a registry, is not considered part of the CDSS intervention cost.
- A CDSS can also change the economic efficiency of the care process by altering either the resources needed to care for a patient or the number of patients cared for with the same level of resource use.

INTERVENTION ECONOMIC BENEFIT

- Effective CDSS interventions reduce CVD risk factors, such as systolic blood pressure
- The reduction in risk factors, in turn, reduces morbidity and mortality and increases the quantity and quality of years lived, measured as quality-adjusted life years (QALYs) saved.
- The impact of CDSS on health care cost is the difference in the cost of health care products and services used by the intervention and control groups or the pre to post change where there is no control group.

INTERVENTION ECONOMIC BENEFIT

- Implementation of a CDSS can increase or decrease health care utilization by the patient, owing to either adherence to guidelines for care (increased cost) or improved health (decreased cost).
- The sum of these 2 changes is observed in changes in the component cost of outpatient, inpatient, and emergency room (ER) visits, medications, and labs
- A full accounting of health care cost would include all 5 of these components
- Reduced illness and increased years of life lived contribute to fewer illness-related absences from work, better performance when present, and a longer period of productivity.

SUMMARY ECONOMIC OUTCOME

- Cost-benefit analysis compares economic benefit to intervention cost, where both benefit and cost are monetized and expressed in dollar terms; an intervention is cost-beneficial when economic benefit exceeds intervention cost.
- Net cost (intervention cost plus health care cost) per QALY gained produces cost-utility, which is a type of cost-effectiveness assessment.
- An intervention is cost-effective when net cost per QALY gained is <$50,000

MEASUREMENTS, METRICS, AND REVIEWER DECISIONS

- Intervention cost can differ for practices of different sizes, because the scale of CDSS implementation ranges from small clinics to large health centers.
- The review team decided that intervention cost should be characterized by the size of practices where the CDSS is implemented.
- this review did not find any studies that fully characterized the association between cost of CDSS implementation and size of practice, whether based on number of physicians or patients in the practice.

MEASUREMENTS, METRICS, AND REVIEWER DECISIONS

- based on number of physicians. American Medical Association
- Small, 1–4 physicians (40% of respondents);
- medium, 5– 24 physicians (35% of respondents);
- large, 25 physicians (25% of respondents)
- For studies that reported only the number of patients we estimated the number of physicians based on an average patient panel and workload of US primary care physicians.

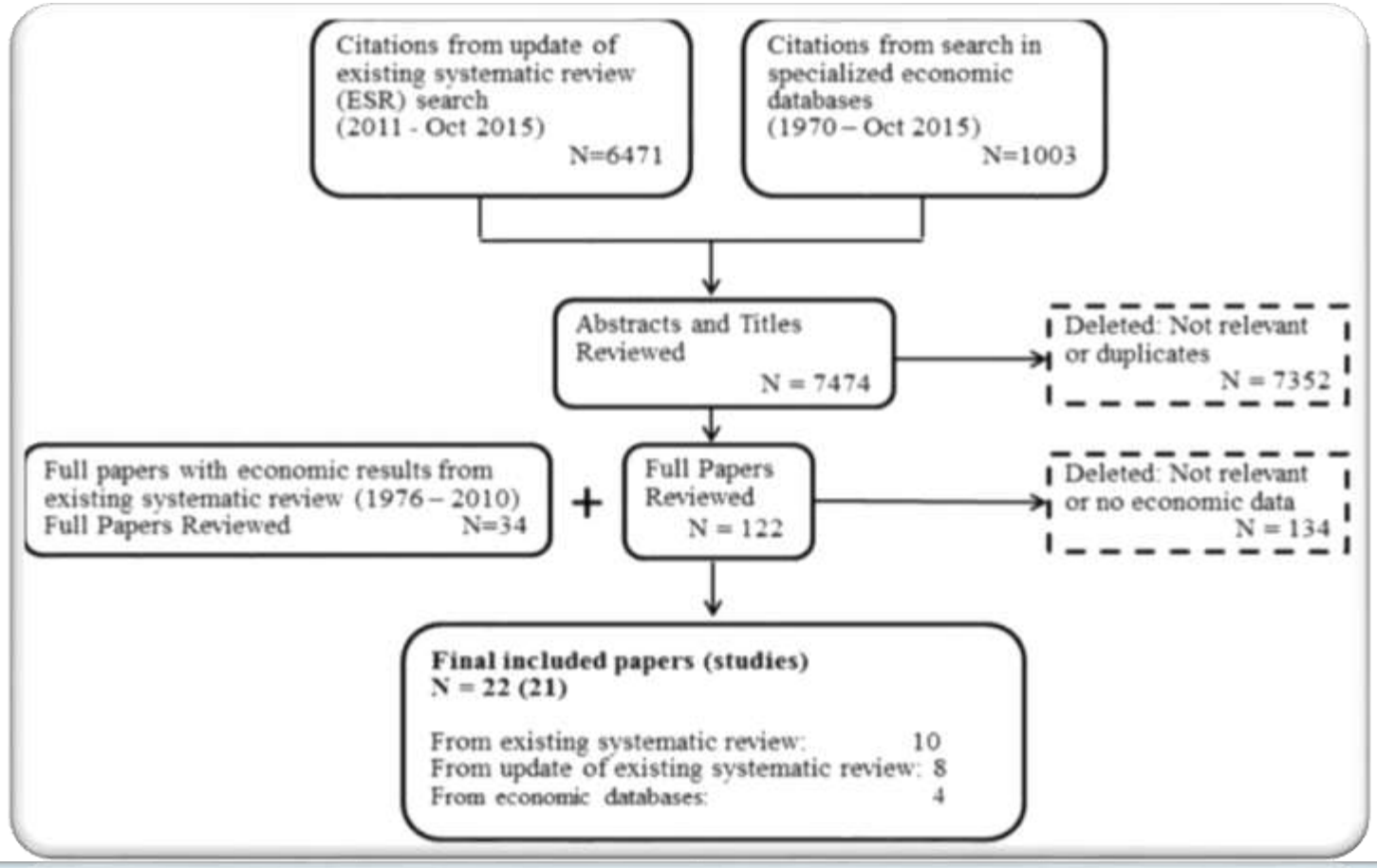
MEASUREMENTS, METRICS, AND REVIEWER DECISIONS

- All monetary values were converted to 2015 US dollars. The Consumer Price Index from the Bureau of Labor Statistics was used to adjust for inflation.
- Results are summarized using medians and interquartile intervals.

RESULT

- Twenty-one studies from the 7508 papers screened met the inclusion criteria.
- Seventeen studies reported on EHR-based CDSSs.
- 1 study piloted a CDSS residing on a stand-alone desktop.
- 1 was based on a diabetes registry.
- 2 studies covered both EHR-based and registry-based CDSSs.

RESULT


Citations from update of existing systematic review (ESR) search (2011 - Oct 2015) N=6471
Citations from search in specialized economic databases (1970 – Oct 2015) N=1003
Abstracts and Titles Reviewed N = 7474
Deleted: Not relevant or duplicates N = 7352
Full papers with economic results from existing systematic review (1976 – 2010) Full Papers Reviewed N=34
+
Full Papers Reviewed N = 122
Deleted: Not relevant or no economic data N = 134
Final included papers (studies) N = 22 (21)
From existing systematic review: 10
From update of existing systematic review: 8
From economic databases: 4

RESULT

- Most of the studies were based in the United States (67%) and implemented in clinics (94%), based on trials with a control Group(63%) or models based on trials (25%).
- The studies covered CDSSs implemented alone (36%), or in combination with patient reminders/education (18%) or with team-based care (23%).
- Most studies focused on diabetes as a risk factor (47%), followed by other CVD risks. More than 90% of the studies were published since 2000.

RESULT

Table 1. Characteristics of included studies and proportion of studies with each characteristic

Characteristic	No. of studies (% of all reviewed studies)
Country	
United States	14[16,20,22–24,26–28,30–33,35–37] (67%)
Non-United States	7[17–19,21,25,29,38] (33%)
Setting	
Clinic	18[16–25,27–33,35,37] (86%)
Hospital	3[26,36,38] (14%)
Study type	
Trial	15[16,17,19,20,23,24,26–30,35–38] (71%)
Model	1[32,33] (5%)
Trial + Model	4[18,21,22,25] (19%)
Survey	1[31] (5%)
CDSS risk factor focus	
Diabetes	10[18,22,25,28,30–33,36–38] (47%)
Hypertension	1[24] (5%)
Hyperlipidemia	2[17,19] (10%)
Hypertension and hyperlipidemia	1[21] (5%)
Including multiple CVD risk factors	7[16,20,23,26,27,29,35] (33%)
Control group	
Pre and post with no control group	5[17,27,36–38] (24%)
With control group	14[16,18–26,28–30,35] (67%)
Survey, model with no control group	2[31–33] (10%)

Intervention added to CDSS	
Team-based care	5[18,24,28,36,38] (23%)
Provider incentives	2[22,35] (9%)
Provider audit and feedback	1[21] (5%)
Patient phone reminders or report to patient	4[20,23,31–33] (18%)
Quality improvement	2[35,37] (9%)
None	8[16,17,19,25–27,29,30] (36%)
Publication period	
1990s	2[20,26] (9%)
2000s	9[16,17,19,21,24,28,30–33] (43%)
2010s	10[18,22,23,25,27,29,35–38] (48%)

INTERVENTION COST

- Twelve studies reported estimates of intervention cost, which are presented for registry- and EHR-based CDSS implementations.
- The estimates are characterized further by size of the health care practice and whether studies included cost of development and implementation, ongoing cost of operations, or both.
- Nine of the 12 studies reported the intervention cost of CDSS implementation specifically.

INTERVENTION COST

Table 2. Intervention cost with components and characteristics of CDSSs

Study	Size[a]	Development and Implementation Cost Included	Ongoing Cost Included	Reasonably Complete Estimates	Annual Cost[b] (5-year life)	
					Per Patient	Per Practice
Registry-based						
Adler-Milstein 07[31]	Small	Y	Y	N	$69	$9511
Adler-Milstein 07[31]	Medium	Y	Y	Y	$23	$20,649
Adler-Milstein 07[31]	Large	Y	Y	Y	$14	$75,964
Blanchfield 06[30]	Medium	Y	Y	N	$106	$132,438
Bu 07a,b[32,33]	Small	Y	Y	Y	$55	NR
EHR-based						
Adler-Milstein 07[31]	Medium[c]	Y	Y	Y	$56	$49,808
Bardach 13[35]	Small	N	N	N	$9	$18,650[d]
Bu 07a,b[32,33]	Small	Y	Y	Y	$170	NR
Cleveringa 10[18]	Small	Y	Y	Y	$73	$4794
Fretheim 06[21]	Small	Y	N	N	NR	$346
Gilmer 12[22]	Medium	Y	Y	Y	$43	$20,595
Khan 10[23]	Small	Subscription fee	Subscription fee	Y	$63	$7318
Munoz 12[36]	Large	N	N	N	$61	$386,750[e]
O'Reilly 12[25]	Small	Y	N	N	$27	$3739
Shih 11[27]	Small	Y	N	N	$4	$7053
Zamora 13[29]	Small	NR	NR	N	$225[f]	NR

INTERVENTION COST

- Of the remaining 3 studies, 2 that provided the cost of intervention did not include the cost of CDSS, with 1 reporting the cost of adding provider incentives to the CDSS implementation and the other providing only the labor cost of the staff involved in team-based care.
- All 3 studies that assessed the cost of CDSSs implemented in diabetes registries included both the one-time capital cost and ongoing operations cost.

INTERVENTION COST

- Based on a survey of users and vendors, 1of the studies estimated that the annual cost per practice for a registry based CDSS was about $9,500 for small, $20,600 for medium, and $76,000 for large.
- The corresponding estimates for cost per patient per year were $69, $23, and $14, respectively.

INTERVENTION COST

- Eight studies reported the intervention cost of EHR-embedded CDSS, of which 5 included both the cost of development and implementation and the ongoing cost of operation, and 3 included only the one-time cost of development and implementation.
- Among the 5 studies that provided reasonably complete assessments of intervention cost, the mean annual costs were $102 per patient and $6056 per practice for small practices, and $49 per patient and $35,per practice for medium-sized practices.

CHANGE IN HEALTH CARE COST

- Change in health care cost attributable to the intervention was reported in 15 studies: 13 EHR-based implementations, 1 registry-based, and 1 reporting both types .
- Interventions in addition to the CDSS were present in several studies; therefore, the effect on health care cost and other outcomes cannot be attributed to the CDSS alone.
- Based on 8 studies that included at least 3 of 5 components of health care cost, the median change in health care cost per patient per year was $35

CHANGE IN HEALTH CARE COST

Table 3. Health care cost: components and estimates

Type of CDSS Study	Additional Intervention	Time Horizon	Components					Reasonably Complete Estimate	Change in Health Care Cost Per Patient Per Year[a]
			Outpatient	Inpatient	ER	Drugs	Labs		
Registry-based									
Blanchfield 06[30]	None	1 year	✓			✓	✓	Y	+$6
Bu 07ab[32,33]	Patient reminders	10 years	✓	✓				N	−$127
EHR-based									
Apkon 05[16]	None	2 months	✓			✓	✓	Y	+$355
Bassa 05[17]	None	1 year	✓			✓	✓	Y	−$133
Bu 07ab[32,33]	None	10 years	✓	✓				N	−$94
Cleveringa 10[18]	TBC	10 years	✓	✓		✓		Y	All patients: +$148; patients with CVD: +$98
Cobos 05[19]	None	1 year	✓			✓	✓	Y	−$107
Frame 94[20]	Patient reminders	2 years	✓					N	$0
Fretheim 06b[21]	Provider audit and feedback	1 year				✓		N	−$10
Gilmer 12[22]	Provider incentives	40 years	✓	✓		✓		Y	−$46
Herring 13[18]	TBC	9 months		✓				N	−$539
Khan 10[23]	None	32 months		✓	✓			N	−$236
Murray 04[24]	TBC	1 year	✓	✓	✓			Y	−$2986
O'Reilly 12[25]	None	40 years		✓	✓	✓		Y	−$23
Oxendine 14[37]	Quality improvement	1 year		✓	✓			N	+$6532 during intervention −$1960 1 year post
Smith 08[28]	TBC	1 year	✓	✓				N	Outpatient was −$349 Total with

WORKSITE PRODUCTIVITY

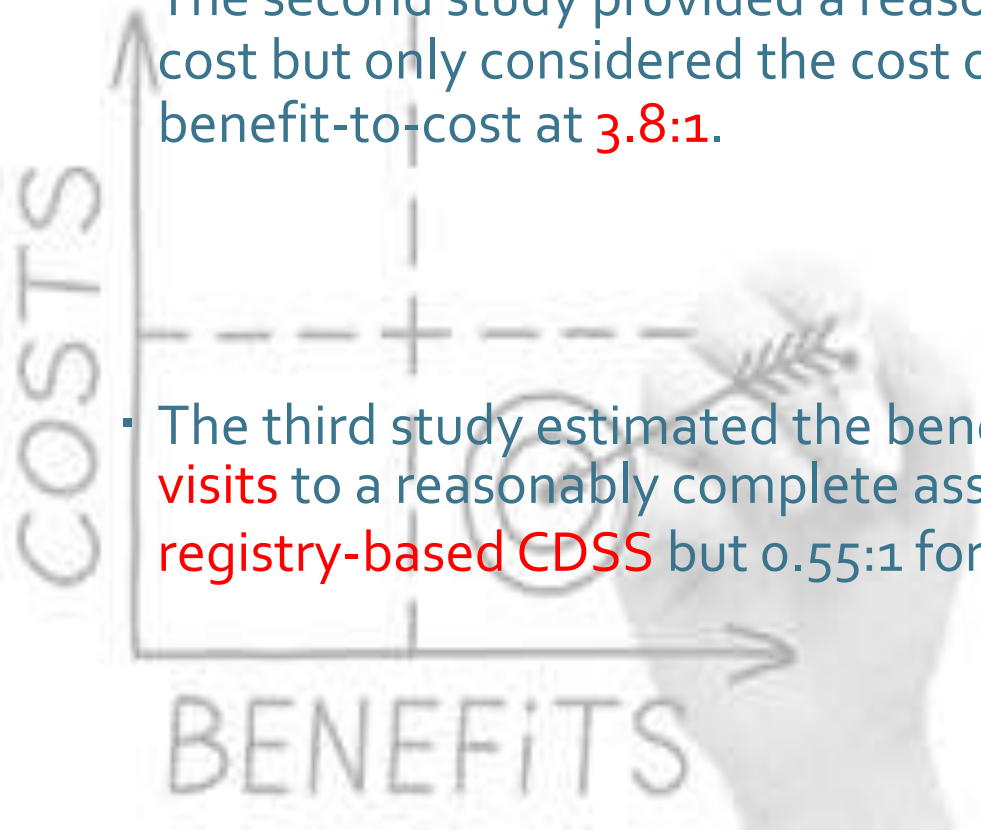
- No studies assessed the economic benefit of worksite productivity improvements for patients whose health improved through use of a CDSS.

COST-BENEFIT AND COST-EFFECTIVENESS

- Economic benefit was compared to intervention cost in 2 studies of EHR-based CDSSs and 1 study of both EHR- and registry-based CDSSs .
- All 3 studies included fewer than 3 components of health care cost and did not estimate productivity effects; they were therefore incomplete assessments of economic benefit.
- One study that reported a benefit-to-cost ratio of 2.03:1 considered only the averted cost of medication and did not include ongoing operating cost in its estimate for intervention cost.

COST-BENEFIT AND COST-EFFECTIVENESS

- The second study provided a reasonably complete assessment of intervention cost but only considered the cost of inpatient stays and ER visits, estimating benefit-to-cost at 3.8:1.



- The third study estimated the benefit of averted inpatient stays and outpatient visits to a reasonably complete assessment of intervention cost at 2.3:1 for a registry-based CDSS but 0.55:1 for an EHR-based CDSS.

COST-BENEFIT AND COST-EFFECTIVENESS

- In summary, the results from cost-benefit studies are incomplete assessments and indicate mixed conclusions on whether economic benefits exceed the cost of CDSS interventions to prevent CVD.
- Three studies provided estimates of cost per QALY saved , where the same time horizons were used for net cost and adjusted life years lived outcomes:

COST-BENEFIT AND COST-EFFECTIVENESS

- 2 reported that the interventions were cost-effective at $49,000 and $16,500 and 1 reported that it was not cost-effective at $143,000.
- Estimates for health care cost from all 3 studies were reasonably complete, but 1 study did not include annual operating cost in the intervention cost

Study Type of CDSS	Cost per QALY saved
Cleveringa 10[18] EHR-based	All patients –$49,500 Patients with CVD –$19,600 Patients without CVD –$162,000
Gilmer 12[22] EHR-based	$16,500
O'Reilly 12[25] EHR-based	$143,000

CDSS, clinical decision support system; CVD, cardiovascular disease; EHR, electronic health record; QALY, quality-adjusted life year.

DISCUSSION

- This systematic economic review of one type of health information technology, namely CDSS, encountered similar difficulties among others in synthesizing the economic evidence from various implementation instances.
- The cost and economic benefits of CDSS implementations from included studies were poorly reported, and many studies did not adhere to sound evaluation or accounting practices.

DISCUSSION

- Only a few studies provided a complete accounting of cost to develop, implement, maintain, and operate a CDSS.
- More complete economic evaluations are necessary to obtain reliable estimates for intervention cost across types and sizes of health care settings.

DISCUSSION

- Reported economic benefits of a CDSS are often determined or guided by the implementation's disease or risk-factor focus (eg, hypertension, CVD, diabetes, depression), functionality (eg, provider prompts, management of orders, disease management), or the implementer's objective (eg, containing cost with cheaper drugs or averting hospital readmissions).

DISCUSSION

- The results presented in the current review are consistent with those found in the broader review of evidence for CDSS implementations for all diseases and conditions. That review found that CDSSs/ Knowledge Management Systems reduced health care cost and produced cost-savings, but it reached mixed conclusions about cost effectiveness.

CONCLUSION

- An overall conclusion cannot be reached about the cost-effectiveness or cost-benefit of CDSSs for CVD prevention and control.
- The evidence on cost and benefit is limited by many estimates that do not account for major components, and mixed evidence when the estimates are reasonably complete.
- The quality of economic evidence for CDSSs can improve with more evaluations.

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COMPETING INTERESTS

- The authors have no competing interests to declare.

CONTRIBUTORS

- All authors contributed substantially to the conception and design of the work. VJ, ABT, SKC, GJN, KKP, and DPH drafted the manuscript, and all authors contributed to revising it critically for important intellectual content. VJ and SKC contributed to acquisition, analysis, and interpretation of data. All authors have approved the manuscript for publication and agree to be accountable for all aspects of the work.

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SUPPLEMENTARY MATERIAL

- Supplementary material is available at Journal of the American Medical Informatics Association online.

Thanks for Your Attention

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