Cardiovascular Disease Prevention and Control: Clinical Decision-Support Systems (CDSS)

Summary Evidence Table – Economic Review

Study	Study and Population Characteristics	Intervention Description	Health Effects	Program Costs	Healthcare Costs Averted Productivity Losses Averted	Full Economic Summary Measure
Author (Year): Adler-Milstein et al. (2007) **Study Design:** Intervention Cost Only **Disease Outcomes:** Diabetes **Setting:** Primary Care and HMO Setting **CDSS Function:** Diabetes Mgmt **Adjustment to 2012 U.S Dollars:** US$. No base year	**Study Location:** Nationwide, USA **Sample Size:** Of 38 users that agreed to interviews, the distribution were: Registry – 14 users, 2 vendors CDS – 1 user, 0 vendors Payer-based – 4 users, 4 vendors	Survey and review of literature for DM2 management software and implementation cost. Collected from literature review, vendor and provider interviews. Interviewees drawn from Disease Management Association of America direct request for interviews from members. We focus on 2 provider-based systems and 1 payer based system. Stand-alone Registry	Not evaluated and not reported.	**Registry** One-Time Cost Patient Identification (set up and run query) –Interfaces (to billing system for demographic and medical claims, to claims for pharmacy and labs) –1 PC per physician/patient –Training (3 hours/physician and 8 hrs/program manager) Annual Cost Software License Fee (includes IT support) PC Replacement Interface	We place the payer system here under healthcare cost for lack of space. **Payer Outsourced DM System** One-time Cost Patient Identification Implementation Fee Implementation Support Staff (Program manager, IT staff, staff physician) Annual Cost Identification Refresh Per Intervened Member Per Month Fee (varies by insurance status) Ongoing Support staff	We place the registry system here under healthcare cost for lack of space. Small Practice (2 MDs); Medium Practice (10–15 MDs); Large Practice (76–99 MDs) **Registry with Reminders** Cost per practice (Cost per Diabetic) Small # Diabetics 137; Acquisition Cost 35,900 (262); Annual Cost 7,600 (55) Medium # Diabetics 890; Acquisition Cost 40,500 (46); Annual Cost 16,500 (19) Large # Diabetics 5,440; Acquisition Cost 68,700 (13); Annual Cost

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provided. Used 2004 as base year. CPI-1.215		EHR-enabled CDS Payer-based System Payer-based systems are often outsourced and mine the claims data to identify patients whose treatment don't meet guidelines and prompts are sent to both patients and providers.		Maintenance New Staff Training 4 Mailings Per Diabetic ($1/each) **CDS** One-Time Cost –10 hrs Endocrinologist –200 hrs IT Staff (code guidelines and associated forms and order sets) Annual Cost Maintain and update guidelines –1/3 Program Manager –10 hrs Endocrinologist –40 hrs IT Staff	**Payer Outsourced DM System** Cost per Payer (Cost per Diabetic) Small (5-10K lives) # Diabetics 211; Acquisition Cost 313,000 (1483); Annual Cost 168,000 (796) Medium (50-75K lives) # Diabetics 1,909; Acquisition Cost 313,000 (164); Annual Cost 708,000 (371) Large (440-500K lives) # Diabetics 13,740; Acquisition Cost 576,000 (42); Annual Cost 3,230,000 (235) Payer-based CDS charged Per Intervened Member Per Month fees that ranged from Commercial $17–$27; Medicare Managed Care $40–$70; Medicare	60,700 (11) **EHR with CDS** Cost per practice (Cost per Diabetic) Small # Diabetics 136; Acquisition Cost 11.600 (85); Annual Cost 39,800 (293) Medium # Diabetics 882; Acquisition Cost 11,600 (13); Annual Cost 39,800 (45) Large # Diabetics 5,396; Acquisition Cost 11,600 (2); Annual Cost 39,800 (7) Note: EHR with CDS assumed preexisting system with no need for identification, interfaces, hardware, or training. Also CDS is assumed 100% scalable with zero variable cost. **5 year cost per person with diabetes** Registry least costly for small and medium sized practices

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					FFS $47–$82; Medicaid Managed Care $25–$40; Medicaid FFS $28–$44.	CDS least costly for large with existing EHR system
Author (Year): Apkon et al. (2005) **Study Design:** RCT **Disease Outcomes:** 24 Common Complaints in GP Visit **Setting:** Military Primary Care Dx and Tx **Adjustment to 2012 U.S Dollars:** US$. Used 2003 base year. CPI-1.248	**Study Location:** Multiple bases in Fort Knox, KY and Mayport, FL **Study Name:** Problem-Knowledge Couplers (PKC) Implemented in general practices within military system. **Sample Size:** Interv-721;Control-704 Age 34-37; female 59-68% **Population Characteristics:** DoD selected two interv bases for the past leadership in CDSS. Patients with no previous coupler sessions, no emergency medical conditions, =>18 years. **Time Horizon:** Recruit ended Dec	CDSS linking knowledge base of prevention/treatment to patient EMR and current complaint or reason for visit. Set up for 24 common complaints with recs derived from USPSTF and AHRQ. Main data entry into coupler by patients (assisted by coordinator) followed by provider review of patient inputs, CDSS diagnosis and treatment recs, and provider entries. Specific couplers existed for each common complaint. Rec made based on patient's EMR, present complaint, and knowledge base. Note PKC is commercial software.	At index visit, C:704 (72.9%) to Interv:721 (77%) patients had 1 or more opportunities for health care, with mean opportunities being Interv:2.54 and C:2.35. Opportunities/processes indicated at index visit tabulated for each patient and 60 days f/u to determine if they were fulfilled In interv, 805 out of 2374 opportunities were fulfilled (33.9%) while 695 out of 2265 fulfilled in control (30.7), but difference not significant. LDL treatment fulfillment was better in control: Interv:13/49 (26.5%); C:18/48 (37.5%) but not	No intervention costs provided.	All costs are 2 month estimates. Median Cost Imaging: Int:$31; C:$29 (Not Signif). Median Cost Labs: Interv:43 Control:$31 (Signif Higher) Median Cost Outpatient Visits: Interv:$307:Control:$292 (Not Sig) Median Cost Medications: Interv:$203 Control:$164 (Signif Higher) Median Total Health Care Cost: Interv:$789 Control:$698 (Signif Higher). Multivariable logarithmic mean cost higher for interv group by $46.	No summary estimates provided. Note young patient population. Evaluation of PKC mandated by congress after approval for use in Dept Defense health care, which to date had already spent $15 million piloting in 75 hospitals and 450 clinics. Eval required RCT.

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	31 2002. Interv f/u was 2 months. Interv length was 2 months.		significant. Fulfillment rates by providers better in interv group for A1c and SBP but Very small samples to make a determination about effect. There was no difference in patient satisfaction. Provider's significantly agreed that CDSS provided high quality info, but disagreed that time involved in use was reasonable and disagreed that it improved patient-provider interaction, improved decision, or improved patient care.			
Author (Year): Bassa et al. (2005) **Study Design:** CVD Prospective Natural Experiment	**Study Location:** Barcelona, Spain **Study Name:** OptimCare **Population Characteristics:** Randomly selected from patients of a	Appears to be practice based. Spanish national guidelines for recommended diet, drug therapies and tests for HC. ElecHR embedded, onscreen prompts,	1 year pre to post change. Median LDL reduced 10 mg/dL (95% CI –14, –6) Percentage treated with lipid-drugs reduced 15.6% (95% CI –11.4, –19.7)	No program cost provided.	**Change in cost per patient pre to post (annual)** Lab costs increased E5.4 (2.0, 8.7) HC-related visits reduced E16.5 (–19.7, –13.4) Lipid drugs cost reduced E67.2 (–	No full economic summary measure. However, note the improvement LDL control while total health care costs were reduced.

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Healthcare cost only **Disease Outcomes:** LDL **CDSS Function:** Primary Care Guidelines **Adjustment to 2012 U.S Dollars:** Euro. Used CPI and PPP with base year 2002 (CPI-1.276; PPP-0.737)	single primary care center with diagnosis for hypercholesterolemia (HC) in the pre period. Median age 67; Female 66%. 100% with HC; CD-13.6-14.6%; HTN-57%; DM 17-18%; 60% with 2 or more CVD risk factors. **Sample Size:** 500 Selected for analysis from 1088 (404 with post measure of LDL actually evaluated) **Time Horizon:** Recruit start Oct '99. Each patient with 1 year pre and 1 year post data. Interv. length 1 year	unclear if automated or user-initiated. Physician accepted CDSS algorithms, could reject suggestions but had to provide reason.	Percentage meeting treatment LDL goal increased 11.9% (95% CI 5.9, 17.8)		83.1, –51.4) Total health care cost reduced E78.4 (95% CI –94.7, –62.1). No productivity improvements considered.	
Author (Year): Blanchfield et al. (2006) **Linked Study:** Grant et al. 2003, 2004 Intervention Cost and	**Study Location:** Boston, MA Developed at MA General. **Sample Size:** N=1250 in DM2 registry.	POPMAN Web-enabled registry-based CDSS developed for DM2 management in primary care. Once implemented, Nurse Practitioner performed weekly population review.	See Grant 03, 04 Guidelines Followed I:59%; C:45% Improved Testing HbA1c: I:+1.4%,C:-1.4% LDL: I:+14.7%, C:+4.0% Additional persons	Focus of this study is the cost of development and implementation, collected during controlled trial of population-based DM management.	Short term 20 month patient utilization estimates compared for community health center using CDSS to control clinics. Authors note this is	**Intervention Cost (Over 4 years)** Design and Development (2.5-3.0 Yrs): $189,975 Implementation and Education (1.5-2.0 Yrs): $64,256 Clinic Operations: $86,004 IT Support (2 Yrs):

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Partial Healthcare Cost **Disease Outcomes:** Diabetes Management **Setting:** Primary Care **Adjustment to 2012 U.S Dollars:** US$. No base year provided. Used 2002 as base. CPI-1.276	**Time Horizon:** Design started April 00 with Release 1 in July 01.		with HbA1c Controlled I:10.5%, C:4.8%	**Design and Development Cost** Model Devep – 6 months among physicians, IT staff. Prototype Dvp and Tech Support Subsequent Releases Project Mgmt **Implementation and Education Cost** Based on establishing in community health center and training physicians and population manager in its use. Primarily labor of data analyst, non-population manager, temporary nurse staff, the population manager, physicians, CS	expected to be an increased cost in the short run due to CDSS. Savings are from LT outcomes that require modeling. Total cost of selected tests increased: $3540 per year Study notes an increase in healthcare cost of $7080 as part of POPMAN cost. (Not clear if this is for a year or what period it covers). Assume this is for tests and outpatient visits.	$107,688 Total: $447,823 **Per Patient Basis (Assuming N=1200)** ~$450,000 ($379 per patient) to develop and operate over 3.5 years Of this, $250,000 is sunk cost Annual Operating Cost: $90 per patient Authors provide estimates to modify POPMAN for other chronic diseases: Design & Development: $50K–$150K; Implementation & Education: $30K–$50K; Clinic Operations: $40K; IT Support of $60–$70K for registry of 1200 patients Authors conjecture that the costs would be less than revenue gains from pay for performance.

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				Library staff. **Clinical Operating Costs** Primarily labor for population manager, medical records review nurse, data analyst, physician coordinator and users plus overhead and supply **Ongoing IT Support Costs** CS labor provided project management, data monitoring, tape backups, network support, updates, and modifications.		
Author (Year): Bu et al. (2007) **Study Design:** Model	**Study Location:** National Model **Study Name:** ITDM **Time Horizon:** 10 Year simulation 20%	IT enabled diabetes care modeled separately for registries, computerized clinical decision support, remote monitoring and self-	Process outcomes of care occur within 12 months of implementation (evidence-base studies were 12 month duration)	No intervention costs provided. Study states these estimates are published elsewhere (citation #39 not found in	Not reported separately but savings are generated from effects on health care utilization by prevention of events such as	LT modeling assumed 5% discount. Costs based on CDC-RTI model updated. **Cost of Care Savings (per enrolled) patient Over 10 Years**

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CDSS Function: Model Diabetes Management Registry, CDSS, Payer-Systems Registry, CDSS, Self-Care, Remote Monitoring, Composite **Adjustment to 2012 U.S Dollars:** US$. Base year 2004. CPI-1.215	implementation annually with full national scale at year 5. **Population Characteristics:** All insured persons in US diagnosed with DM2 eligible. Exclude DM1; <25 years age; uninsured; undiagnosed with DM2. Baseline based on DM2 population of US: Age 52-53; Ethnicity; Female-55%; **Baseline Values and Rates** A1c-7.6%;SBP-~153;TotalChol-~211; Eye exam rate-14.2%; Foot exam rate-44.9%; Microalbuminuria screening-45%.	management technologies, and payer-sponsored technologies. Also evaluates the suite of capabilities. Model based on 4 engines: impact of care process, impact on disease, impact of patient migration between plans and systems, scaling effects to national level. Calibration by systematic evidence review. Main effects through control of BP, A1c, Cholesterol, compliance with foot, eye, microalbuminuria screening.	12 month Post Intervention Values and Rates (Sustained in modeling) **Care Process Outcomes Registries (CDSS) [Payer Systems]** Eye exam:61.5% (24%) [26%] Foot exam:80% (68%) [58%] Microalbuminuria screening:66% (61%) [53%] **Patient-centered systems** had no effect on process outcomes. **Clinical Outcomes Registries (CDSS) [Payer Systems]** A1c: reduced by 0.50% (reduced by 0.28%) [reduced by 0.24%] SBP: reduced by 1.1 mmHg (increased by 4	reference list)	cardiac complications and stroke. Authors state that some important elements not included in the CDC-RTI disease progression model. Productivity effects not considered.	DM2 registries: $14.5 billion ($1,016) CDSS: $10.7 billion($752) Payer-centered technologies: $7.10billion ($558). Remote monitoring: $326 million ($130) Self-management: $285 million ($34). Integrated providerpatient systems: $16.9 billion ($1,180). In sensitivity analysis, when CDSS effect on SBP was assumed to be neutral, the additional savings were $1.2 billion for a total of $12 billion, due to reduced cardiac complications and stroke rates. Registry-based care management was most effective in its ability to interact with patient, provider, and point of care. CDSS were the next most effective, followed by payer systems.

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			mmHg) [reduced by 5.4 mmHg] TotChol: reduced by 31 mg/dl (reduced by 4.5 mg/dl) [reduced by 11 mg/dL] **Patient-centered Remote Monitoring (Self-Management)** A1C: Reduced 0.30% (reduced 0.020%) SBP: Reduced 0.56 mmHg (No change) TotChol Reduced 2.8 mg/dL (reduced 7.9 mg/dL) 10-year mortality reduction was <1.0% for all systems.			
Author (Year): Cleveringa et al. (2010) **Linked Study:** Cleveringa et al. 2008	**Study Location:** Nationwide, Netherlands **Study Name:** Diabetes Care Protocol (DCP) **Sample Size:** Int:1699;Cntr:1692	Research based Controls received usual diabetes care under GP or nurse Intervention was complex including a CDSS, a recall system, feedback,	**1-Yr Effect from RCT** LDL Reduced 2.7 mgdL (converted from 0.15 mmol/l) A1c Reduced 0.07 PctPt SBP Reduced 3.3 mmHg DBP Reduced 2.2	Intervention cost included DCP development and implementation; DCP nurse instructions; GP's DM care reorganization; CDSS with recall for DM; 3-	Healthcare related to diabetes complication (retinopathy, neuropathy, amputations, blindness) and CVD and CHD outcomes. Also include drug costs	**Cost per QALY** E38243 for all patients E14,814 for those with CVD history E121,285 for those without CVD history The Dutch DM2 population is about 1 million. Hence, the cost

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Study Design: RCT based CUA Model **Disease Outcomes:** CVD BP, A1c, LDL **CDSS Function:** Primary Care Guidelines **Adjustment to 2012 U.S Dollars:** Euro. Used base year 2006 (CPI-1.139; PPP-0.88)	from 55 practices (I:26;C:29) **Population Characteristics:** Patients in multiple general practices with diagnosis of DM. Mean age-65; Female-50-52%; Caucasian-98%; DM-100%; CVD history:(I 47%, C 63%) Inter period March 05 to Aug 07. **Time Horizon:** Duration 1 year for each patient from date of diabetes visit with GP.	and case management. CDSS based on Dutch Diabetes Care Protocol	mmHg 10-Yr UKPDS CHD Risk Reduced 1.4 PctPt 10-Yr Modeled QALY Increase in QALY 0.037 for all patients 0.07 for those with CVD 0.014 for those without CVD	monthly feedbacks. **10-Yr Modeled Program cost of DCP:** E316 for all patients E314 for those with CVD E319 for those without CVD [Composed of DCP Development Cost plus cost of pilot study translates to E1/patient based on Dutch DM Population; Implementation Cost was E90/patient/year (participating DM population) for first 3 years and E12/patient/year for years 4-10]	(HTN, cholesterol, and diabetes medications were I: E326.30 C: 325.10 in 1 yr f/u). **Based on 10-Yr Modeled** **All Patients** Healthcare Costs: E1698 higher for DM; E587 lower for CHD; E1111 higher for all health. Intervention DCP Cost: E316 higher Total cost:1415 higher Total cost for those with CVD: E1037 Total cost for those without CVD: E1698	of development of the CDSS was E1 million.
Author (Year): Cobos et al. (2005) **Study Design:** RCT Healthcare cost only	**Study Location:** Spain (Catalonia) **Study Name:** CDSS for European Society of Cardiology and other societies for Hypercholesterolemia Management (ESCHM)	CDSS plus patient education through refrigerator magnets, table cloths. EHR embedded CDSS treatment algorithm for meds and diet for those with HC	Post only LDL Reduced 2.7 mgdL. Increase in those meeting goal 3.53 pct pt Neither were significant.	Cost of CDSS not provided.	Treatment Costs Adjusted costs of lipid drugs per patient per year: C:E237; I:E178 Total health care costs per patient per year (Outpatients visits, Lab costs, and lipid	No summary measure provided

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Disease Outcomes: LDL **CDSS Function:** Primary Care Guidelines **Adjustment to 2012 U.S Dollars:** Euro. Used base year 2002 (CPI-1.276; PPP-0.737)	**Sample Size:** I:1046;C:1145 from 42 general practices. **Population Characteristics:** Mean age 60 and 56.80% female. Patients with TC>200 mg/dL but <400 triglyceride. 46% with HTN, 16.20% with DM, 100% with hypercholesterolemia, 40.2% with CV Risk>20% or CHD **Time Horizon:** Recruit start April 00 end May 01. F/U May 02. 1-year intervention	Developed with staff input, based on Workstation, and OnScreen prompts.			drugs): I:E223;C:E283. Most of the difference was due to lipid medication treatment and there was little difference between control and interv for visits and lipid assessments.	
Author (Year): Frame et al. (1994) **Study Design:** Pre-Post **Disease Outcomes:** BP, Weight, Tobacco, LDL etc.	**Study Location:** Dansville, NY **Study Name:** HTRAK General practice with 5 rural locations. Recruited from among all patients. **Sample Size:** I:829;C:836 **Population**	CDSS-based patient reminder and provider reminder for 11 tests/checks including: Tobacco, BP, Cholesterol, Immunization, FOBT, BreastExam, Mammography, Weight, Osteoporosis, Pap. Internally developed CDSS linked to billing through provider data entry in	BP and weight already high at base and decreased in post. Note nurses not targeted by provider reminders. PctPt Change in Tests/Orders: Overall: I-13.5%, C-3.3%. BP and Weight Already high at base and	Cost of developing CDSS not provided. Cost of maintaining and operating CDSS stated to be total of $780 per 1000 patients with 2/3 being cost of patient reminders. There was 2 hr training but cost not included. Operating costs	Study states there was no difference in visits/billings. The analysis is based on sample of I:829 and C:837. Change in annual total # visits: decreased 108 for interv and increased 74 for control. However, change in annual billings: Increased	No economic summary measures reported.

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CDSS Function: Test Reminders Incomplete cost analysis Primary Care **Adjustment to 2012 U.S Dollars:** US$. Used base year 1992 (CPI:1.636)	**Characteristics:** Mostly low-income blue-collar; about 62% with some insurance. **Time Horizon:** 2 year intervention during 1991 through 1992	patient encounter forms. Standalone system. Paper annual report placed in each patient chart. Control used manual tracking system	decreased in post. Cholesterol test increased 17% for I 11% for C. All other tests increased compared to control: Self-exam; Pap; Tetanus; Mammo.	by time motion study. Patient Reminders-$545 per 1000 (53% Postage,30% staff, 17% supplies). Provider Reminders-$234.73 (77.6% staff,22.4% supplies)	$3069 ($3.70 per patient) for Interv and increased $8269 ($9.88 per patient) for control.	
Author (Year): Fretheim et al. (2006b) **Linked Study:** Fretheim et al. 2006a **Study Design:** RCT+Model **Disease Outcomes:** HTN, Cholesterol Control, CVD Risk Primary Care Drug Choice **Adjustment**	**Study Location:** Oslo and Tromso areas, Norway **Study Name:** RaPP **Sample Size:** I:73 [70 Final] practices (3316 [516 final] patients);C-73 [69 Final] practices (2863 [446 final] patients) **Population Characteristics:** Patients with HTN, hypercholesterolomia, but no established CVD. Mean age 61; 51-55% female **Time Horizon:**	CDSS embedded in order system to increase use of cheaper thiazides for HTN. Outreach and edu about guidelines by pharmacists; audit and feedback; computerized reminders during consultation. Usual care received passive guideline through a medical journal article.	PctPt Change in Thiazides Prescriptions (Significant): I:+11.5;C:+2.2. The following effects were insignificant. Treatment goal achieved:I:2.6;C-2.9. CVD Risk Assess Done:2.6pctpt improve in Interv. versus control.	Authors state the cost of guideline development was not considered. Cost per practice (N=70): Software development 366; Training of outreach visitors 245; Printed materials 58; Travel costs 109; Salary of pharmacists doing outreach 287; Administration costs 28; Physician opportunity cost 125; Technical support 98; Drug costs 9.3%	Cost per Rx of HTN Medications Baseline: I:112.89,C:113.53 . Cost per Rx of HTN Medications 1 Yr After:I:103.57,C:111.68. DinD:7.47. With total of 5191 Rx in intervention group, savings was $38773 for the 70 practices ($554 per practice).	**1 Yr Trial Data** Note the intervention cost per practice ($1316) greater than the reduced drug cost per practice ($554). Not cost-saving. **2 Year National Model** 2 Year Cost and Savings Scaled up to national level Interv and effect sustained over 2 years Cost per practice:$1056 Drug savings per practice:$2137 Net Cost per practice: Negative $1081 Key factors for C-B>1.0 include cost of CDSS development constant as intervention was scaled up. May be ok since cost

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to 2012 U.S Dollars: US$. Used base year 2002 (CPI-1.276)	Interv was May-Dec 2002. Pre period was 12 months. 1 yr interv modeled over 2 years			absolute increase in proportion of patients started on thiazides -554 (decrease); Total Cost 763 ($1316 without subtracting the drug cost savings).		of outreach and edu was scaled up in model. Also year 1 patients on thiazides remain switched in year 2 and new patients on thiazides added in year 2.
Author (Year): Gilmer et al. (2012) **Linked Study:** O'Connor et al. (2011) **Study Design:** RCT+Model **Disease Outcomes:** SBP, A1c Primary Care Guidelines **Adjustment to 2012 U.S Dollars:** US$. Used base Year 2009 (CPI-1.070)	**Study Location:** Minnesota, USA **Study Name:** Diabetes Wizard **Sample Size:** 9000 DM patients in general practice. Eval based on 11 GP clinics with 41 PCPs. **Population Characteristics:** Mean age 56.2. Female 49%. White-81%; Black-15%; Asian-4%. Selection criteria patients with DM2 age 18-75 and Charlson comorbidity index less than 3. **Time Horizon:** CDSS implemented in 2007. 1 year f/u for RCT and 40 year horizon for model.	EMR-generated paper report placed on top of visit summary sheet with clinical indicators, treatment recs, contraindications, safety alerts. EHREmbedded internally developed CDSS. Treatment Rec based on algorithm from evidence-based guidelines (Institute for Clinical Systems Improvement) Safety alert for contraindicated treatment, drug interactions. Alert for abnormal lab results or overdue visits. PCP reads wizard generated report before meeting patient and enters visit resolution form in wizard at close of	SBP goal post Only: I-80.2%;C-75.1% (p=0.03). A1c reduced 0.26 (-0.47,-0.06) pre-post versus control No significant change in SBP.	Model assumptions Annual cost of CDSS assumed due to changing practice and technologies. Physician and programmer time to develop CDSS, training time and materials. Provider incentives to use system assumed to be 50% of first year cost in subsequent years (because use of system dropped 50% after removal of incentives and feedback in RCT). Implement & Maintenance (Prog and Phys time)-$19300 every year ($5	Outpatient and drug costs and diabetes-related complications included in modeling. Incr. Hlth Care Cost due to Interv $24-39 Rx Only Outpatient+Rx $102 every year	Lifetime modeled over 40 years for DM2 patients. Cost and clinical outcomes (A1c) from RCT. Long term health events based on UKPDS data. Scenario 3 Base Case: Cost: Usual-$51592;CDSS-$51705:Diff-$113. Lifetime gains due to reduced probability of stroke, ischemic heart disease, renal failure, all cause death. Scenario 3 (Base)Incr QALY-0.04; Scenario 3(Base): $3017/QALY Sensitivity Analyses: Full incentives and training costs persist-$14868/QALY; Interv Effect for 2 years-$40342/QALY; Interv Effect for 1 Year-$56042/QALY. In 2nd order uncertainty analyses ICER was above

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	Intervention was 12 months	encounter. Paper report at each encounter and on-screen visit resolution at close.		per patient for 4086 diabetics in medical group's registry (N= 14,054) not meeting A1c goal); Training & Materials-$5200 Yr1 only; Physician Incentives: $30400 ($76 per patient for 471 individuals who received the A1c intervention) Yr1; $15200 Yr2 onwards ($32 per patient for 471 receiving A1c intervention). Based on above assumptions, the per patient cost $120 to $183 in 3 different scenarios.		$50K only in 8% of simulations. Low cost interv (economies of scale) with effect over large population. Cost-effective over several plausible scenarios. Largest component is provider incentives to change behavior. Per capita interv costs calculated based on different denominators for patient populations – but may be acceptable. Note $/QALY is based on net cost.
Author (Year): Javitt et al. (2005) **Study Design:** Randomized prospective	**Study Location:** Cleveland Metro, OH Deployed in claims data within fee-for-service plan. **Population**	Commercially available system. Sentinel CDSS system based on administrative claims data which sends messages to provider when care deviates from	We focus on two CVD-relevant decision rules that had high frequency issue of recs: Monitor liver function in statin users.	Authors state the deployment of CDSS cost between $1.00 to $1.50 per member per month across all categories of care, depending	Inpatient 12 month Cost Per Admission (ACE for HOPE-CVD related) # persons triggered: I:156;C:155 # Admissions: I:49;C:69	Note there was no statistically significant difference in hospitalizations, LOS, or inpatient charges for non-HOPE triggers. Authors state the ROI >8.0

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controlled trial Healthcare cost only for HOPE patients CVD and other outcomes HMO ACE Inhibitors for HOPE trial eligible. **Adjustment to 2012 U.S Dollars:** US$. No base year provided. Used 2004 as base and US$. CPI-1.215	**Characteristics:** Commercially insured population in university-affiliated managed care plan. **Sample Size:** Patient Population I: 19,739 C: 19,723 Subset Triggering Prompts I: 968 C:1165; Age: 51-53; Female: 53% **Time Horizon:** 12 month intervention.	widely accepted guidelines. Piloted in large fee-for-service plan. Inputs: Claims from physicians, hospitals, outpatient, labs, pharmacy and test results. These inputs compiled as a decision matrix. System included >1K decision matrices. Rule-based recommended decisions from decision matrices sent to providers when care appears to deviate from guidelines. Based on urgency, contact may be by phone, fax, or letter. Triggers for controls not transmitted to providers.	Start ACE inhibitor in HOPE trial qualifiers (Note the HOPE eligibility meets our criteria for inclusion). In terms of outcomes, the lab test outcomes were few b/c they rarely produce direct claims. No effect could be determined. Hence, starting ACE inhibitors is only effect considered here. 908 total recs issues for interv group (775 for control). Of these, recs to start ACE inhibitors was I:156 (C:155). Hospitalizations 12 m (ACE for HOPE-CVD related) Number: I:49;C:69 (p=0.02)	on age of plan population. Unclear what is included in this estimate and how the CDSS cost can depend on age. Assume the cost of interv. is function of the type and number of triggered prompts.	I:$5835;C:$8746 (p=0.05) **Inpatient Charges Interv, V Control In per member terms:** $2061 for 12 months $172 per month (p=0.05)	(Cost of intervention $1.0 pmpm and returns of $8.07 pmpm). Authors note that the prompts lag days and weeks behind the point of care.

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			LOS Days: I:1.4;C:2.2 (p<0.01)			
Author (Year): Khan et al. (2010) **Linked Studies:** Maclean et al. 2004, 2006, 2009; Littenberg et al. 2009 **Study Design:** RCT Partial Cost-Benefit Guidelines **Disease Outcomes:** BP, A1c, Cholesterol control **CDSS Function:** Primary Care **Adjustment to 2012 U.S Dollars:**	**Study Location:** Vermont and part of New York, USA **Study Name:** Vermont Diabetes Information System **Sample Size:** 7412 patients and 132 providers in 64 practices in study. 13 hospital-based labs. Interv:3856;Control:3512 **Population Characteristics:** Age 62-64; Female 50-52%; Creatinine normal 90%. Microalbuminuria present 28-33%;LDL at goal 44-45%; A1c 55-58% at goal. **Time Horizon:** Original RCT was 24 months	Network of labs connected to outpatient GPs and patients. Alerts to patients and providers when tests overdue or when results above target. Flow sheets and guideline based recommendations to providers when lab works done. Connected by net to providers/patients or by fax. Registry of glycosolated hemoglobin A1C, cholesterol, and kidney function results from network of labs that provides decision support based on results to providers and patients from 13 hospital-based labs.	Note that there were no improvements in lipid, BP, A1c, cholesterol or self-care behavior versus control.	$4 per patient per month for VDIS	Post hoc analysis of original RCT by linking patients to Vermont Hospital Discharge Data. NY discharge data not available. ED Charges: I:$304;C:$414;Diff:$110.79 over study period Hospital Charges: I:$3113;C:3480;Diff:$366.95 over study period Interv v control was lower by $14.94 per patient per month for inpatient+ED NY hospitals charges not included. No outpatient and medication costs.	Inpatient+ED Savings v Control was $14.94 per patient per month. Interv Cost was $4 per patient per month. Hence, net savings was $10.94 per patient per month. Savings were higher for males and for seniors. CB ratio is 3.7 for all and higher for seniors.

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US$. No date provided. Used 2002 as base. US$, CPI-1.276						
Author (Year): Murray et al. (2004) Healthcare Cost Only **Disease Outcomes:** BP **CDSS Function:** Primary Care Guidelines **Adjustment to 2012 U.S Dollars:** US$. Used 1997 as base. CPI-1.430	**Study Location:** Indianapolis, IN **Sample Size:** 4 general practice clinics associated with U of Indiana 3 arms of Team-based Care: Physician-led-181;Pharmacist-led-180;Combination-180;Usual-171 **Population Characteristics:** Age 54-56; Female 75-81%; Black-57-61%; Inner city population Those with HTN and on antiHTN meds. Exclude those with major complications. **Time Horizon:** Recruit Jan'94-May'96. Interv. length 12 months	Complex interv with team-based care and CDSS for HTN guidelines (JNC6).	There was no significant improvement in any health outcome: BP control; QOL; ED visit; Hospitalizations	No intervention cost provided. No cost provided for legacy EMR system or cost of additional software development for CDSS.	Outpatient plus inpatient per patient charges were: Usual: $5149; Pharmacist-led:$5445; Physician-led:$6200; Combined:$3122. Largest difference for Combined Interv vs Control but no differences were significant due to enormous variance in estimates.	No summary measures. Focus appears to have been on health care cost impacts.
Author (Year): O'Reilly et al.	**Study Location:** Ontario, Canada	Web-based access for patients and interface with EMR	Reduced LDL by 0.077 (converted from 0.002	Includes infrastructure and hardware;	Modeled using RCT patient characteristics and	Ontario Diabetes Economic Model (ODEM) using outcomes and

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(2012) **Linked Study:** Holbrook et al. 2009 **Study Design:** RCT+Model **Disease Outcomes:** BP, LDL, A1c, CVD, Diabetes **CDSS Function:** Primary Care Guidelines **Adjustment to 2012 U.S Dollars:** Canadian$. Used base year 2010 PPP-1.22; CPI-1.053	**Study Name:** Computerization of Medical Practices for the Enhancement of Therapeutic Effectiveness (Compete II) **Sample Size:** Original RCT in 47 practices with existing EMR in 3 regions of Ontario. 511 patients (I-253;C-258) **Population Characteristics:** Age 61 Female 50% Select those =>18 with DM; A1c 7.0 to 7.1%; smokers 12-16% **Time Horizon:** Interv late 2002 through 2003 12 month interv in RCT-modeled 1, 5, 10 years	for providers, patient reminders, provider diabetes guidelines/protocols	mmol/L); reduced A1c by 0.20%; reduced SBP by 3.95; Based on model, 1-year first event reduced relative risk due to intervention: IHD 8%; MI 7%; Heart failure 5%; Stroke 12%; Amputation 14%; Blindness 7%; Renal failure 9% Modeled based on RCT patients for diabetes complications and UKPDS - MI; amputation; renal failure; stroke, blindness, ischemic HD; heart failure. Based on age, sex, and time-variant BP and A1c. Incremental QALY Assuming no treatment or effect beyond Year1: 0.0117. Treatment and effect over 5 Years: 0.0421. Treatment and effect over 10 Years: 0.0740.	develop and test diabetes tracker, data standard and tech input specs, and ongoing project management during implementation. Authors state their estimate does not include future maintenance cost. Total cost was $483,699 and $1912 per patient for implementation	costs of complications from large Canadian10-year study of 734,113 diabetics. Lifetime costs for disease management: I-$61340;C-$61367 per patient	patient data from COMPETE II trial. **Cost per QALY** Assuming 1 year treatment and interv effect: $160845. Treatment and effect over 5 Years: Incr: $186728. Treatment and effect over 10 Years: Incr: $173654 The intervention is not cost-effective for 1, 5, or 10 year horizons despite the modest savings in lifetime healthcare costs. It appears the $1912 cost of CDSS is encountered each year for the 1, 5, and 10 year model. If the intervention costs don't repeat then the CEAs based on intervention cost alone are below the $50K threshold for both 5 year ($45416) and 10 year ($25838) horizons.
Author (Year): Overhage et	**Study Location:** Indianapolis, IN	Automated fully formed corollary triggered by	Provider compliance with corollary orders	No intervention cost provided. Authors only	No Sig Diff in per patient inpatient Charges:	No economic summary measures.

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al. (1997) **Study Design:** RCT Partial Healthcare Cost **CDSS Function:** Corollary Orders Hospital General Ward Corollary Orders Healthcare cost only **Adjustment to 2012 U.S Dollars:** US$. Used base year 1993. CPI-1.589	Implemented in internal medicine wards in single hospital **Sample Size:** 3 wards each in interv and control. Patients with at least 1 trigger order were 814 in interv and 872 in control. **Population Characteristics:** All admissions to hospital during study period with at least 1 trigger order Age 53-54; female 49-55%; White-49-50%; HTN 5.2-5.6%; CHD 3.2-3.4%; DM 3% **Time Horizon:** Started Oct 1992 Interv length 30 weeks	physician order Built into electronic patient record in hospital Internally developed using standard textbooks and drug package inserts to develop corollary orders for each order. 75% of these were already developed as part of drug utilization review in the past. Physician simply accepts/rejects fully formed corollary order. Physicians already entering all orders online 12 months prior to intervention. Controls and interv physicians got paper copies of corollary orders guidelines. Only interv physicians were prompted online for corollary orders when entering orders.	alerts. Immediate compliance:I-46.3%;C-21.9%;24 Hr compliance:I-50.4%;C-29%;During hospital stay compliance:I-55.9%;C-37.1%. Hospital length of stay (No difference with I:7.62 days v C:8.12 days) Creatinine levels for drug monitoring for renal failure (No difference with I:1.51 v C:1.42). Physician interaction with pharmacist (Pharmacist intervened in 105 interv and 156 control cases of life-threatening interactions).	note that the rules were written by a single author in 2 weeks.	I:$8073.52 v C:$8589.47. Note that only 9.6% of all orders were affected by the CDSS guideline alerts. Also the alerts may have averted some complications.	
Author (Year): Shih et al. (2011)	**Study Location:** NYC, New York, USA	This is a NYC funded project to help GPs adopt	Pre to post changes: HbA1c screening-	Full cost was $20K per provider for	No effects on health care costs reported.	No economic summary measures reported.

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Study Design: Pre-Post Intervention Cost Only **Disease Outcomes:** BP, A1c, Aspirin, Weight etc. **CDSS Function:** Primary Care Reminders for Tests and Procs **Adjustment to 2012 U.S Dollars:** US$. Used 2009 base year. CPI-1.070	**Study Name:** Primary Care Information Project (PCIP) of New York City Pre period from EHR implementation to CDSS implementation. Measurement at 6 months post CDSS. **Sample Size:** 56 practices with established EHR from PCIP pilot project. Reviewers selected 120 random =>18 year old patients records from each practice for pre to post analysis. Most practices saw 1.5-5K patients per year, mean EHR duration was 11 months **Population Characteristics:** Selected practices serving low income Medicaid or uninsured populations-44.3% of patients. Must have patients with Dx of DM, HTN,	EHRs and CDSS. Automated EHR-embedded onscreen prompts. Implementation occurred along with CDSS upgrades. Point of care prompts and guidance for access to an assigned provider; tobacco use; CV health; HIV; depression; substance abuse; cancer screening; vaccinations; environmental health; and reproductive health. Onsite QI support. 29 of the 56 practices received pay for performance in CVD QI. EHR consulting. Revenue cycle optimization. Quarterly feedback on preventive services. Developed by PCIP, Columbia, and eClinicalWorks	48.4% to 64.5%; aspirin therapy-54.3% to 57.8%; Blood pressure control- 49.6% to 56.6%; Cholesterol control- 76.6% to 77.9% BMI recorded-66.7% to 77.9%; breast cancer screening- 29.3% to 37.5%); influenza vaccination-27.1% to 29.6%.	software and $12K for technical assistance. Offered onsite QI coaching, EHR consulting, revenue cycle optimization, and quarterly feedback on preventive services for $4K per provider. Across the 56 practices, most had one to two providers (71.4%) with at least one FTE clinician. We assume 1.5 GPs per practice.		

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	dyslipidemia, or ischemic vascular disease 55% were =>45 years; female 58.80%; HTN 34.50%; CHD 6.00%; DM 14.50%; Hypercholesterolemia 30.90%; smokers 9.70% **Time Horizon:** CDSS upgrade Feb-Aug 2009.					
Author (Year): Smith et al. (2008) **Study Design:** RCT Health care cost only. **Disease Outcomes:** LDL, BP, A1c, Aspirin, Diabetes Primary Care Guidelines **Adjustment to 2012 U.S Dollars:** US$. Used	**Study Location:** Rochester, MN **Study Name:** Diabetes Electronic Management System (DEMS) **Sample Size:** 6 clinics affiliated with Mayo, Rochester (120 GPs with 5468 diabetics in patient panel). During July 01 to Dec 03, 97 physicians and their 639 patients were randomized at first referral. The final analysis was done for: I-49 physicians (358 patients); C-45 physicians (277 patients)	EHR and Chronic Care for diabetes in place and in background. Interv is CDSS telemedicine with specialists (diabetes educators) inputs triggered by gaps in performance in GP care. Educator interacted with GP, patients for self-management and with endocrinologist through DEMS. Objective to manage diabetes, dyslipidemia, BP, and CVD risk. Note the telemedicine with educators replaced specialist consultation in intervention group.	No stat diff for LDL Goal (I-76%,C-82%); no significant effect of interv on office visits, endocrinology consult, calls with DM educator. No stat diff BP Control(I-41%,C-46%); A1c<7%(I-53%,C-56%); 10 Yr Risk of CVD. During period, endocrinologists completed 1361 resulting in 60% leading to advice (message) to GP. 438 (59%) considered the message/advice useful, 364 (49%)	DEMS and CDSS both developed within Mayo. Authors list possible intervention cost components but don't estimate: develop library of evidence-based messages; develop/deploy DEMS; relocating the diabetes educator from specialty to primary care.	Stat diff annual mean cost of outpatient vists: I-$1842; C-$2129; Diff was reduction of $288; Stat diff annual mean cost of all health care: I-$6252; C-$8564. Diff was reduction of $2311. CVD and metabolic Dx accounted for 50% of inpatient costs. Authors state main effect is due to increased elective inpatient for musculoskeletal pain and orthopedic surgery in control (chance occurrence).	No summary measures reported.

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2005 as base year. CPI-1.176	**Population Characteristics:** Age 60-62; female 50-55%; DM 92-94%; A1c 7.30% **Time Horizon:** Average patient duration in interv was 21 months.	Before encounter, endocrinologist provided CVD-related (focus) excerpt for patient from EMR and DEMS data along with evidence guildelines/recs. Endocrinologist wrote 1-2 line rec to GP/patient by email. Usual care only received generic info by e-mail about CVD risk for diabetics.	reported using the message to manage patient Already high performing Mayo clinic with established CCM and DEMS and specialty consultations The only stat diff was in smoking cessation and aspirin use.			