Impact of clinical preventive services in the ambulatory setting

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Indicators of the performance of clinical preventive services (CPS) have been adopted in the ambulatory setting to improve quality of care. The impact of CPS was evaluated in a network of 49 primary care practices providing care to an estimated 245,000 adults in the Dallas–Fort Worth area through a sample chart review to determine delivery of recommended evidence-based CPS combined with medical literature estimates of the effectiveness of CPS. In this population in 2005, CPS were estimated to have prevented 36 deaths and 97 incident cases of cancer; 420 coronary heart disease events (including 66 sudden deaths) and 118 strokes; 816 cases of influenza and pneumonia (including 24 hospital admissions); and 87 osteoporosis-related fractures. Thus, CPS have substantial benefits in preventing deaths and illness episodes.

The prevention of illness and injury is highly valued by the public, patients, physicians, and health care policymakers (1). In the health care setting, immunizations, counseling, and medications may be used to prevent the occurrence of new disease or injury (primary prevention); and laboratory, imaging, or functional tests may detect the presence of asymptomatic disease and lead to treatment to reduce the morbidity or mortality of existing disease (secondary prevention). Preventive services may be provided by physicians, nurses, or others in the ambulatory setting during visits scheduled for the primary purpose of prevention (periodic health examinations) or as the opportunity presents during visits for other indications (opportunistic screening). The US Preventive Services Task Force (USPSTF) of the Agency for Healthcare Research and Quality and the Advisory Committee on Immunization Practices (ACIP) convened by the Centers for Disease Control and Prevention (CDC) have established evidence-based recommendations for clinical preventive services (CPS). Many professional and private organizations also recommend CPS.

Assuring that health care is safe, timely, effective, efficient, equitable, and patient-centered (STEEEP^{TM}) is an urgent priority for the US health care system (2, 3). CPS are recommended throughout life, but specific recommendations vary by age and gender. Measures of the use of CPS are included in the core quality of care indicators established by the Agency for Healthcare Research and Quality, the National Quality Forum, the National Committee for Quality Assurance, the Centers for Medicare and Medicaid Services, the American Medical Association, and other organizations. As Americans receive only approximately 55% of all recommended CPS (4), CPS are a high priority for quality improvement activities in the ambulatory setting.

Ambulatory care practices have adopted measures of use of CPS to monitor quality of care. These performance indicators typically measure the proportion of patients who are eligible for the CPS whose physician has specifically recommended that service, the proportion of patients eligible for a recommended CPS who have received the service, or both. These process measures are simple to understand but have inherent limitations. They assume that deficiencies in care below a target of 100% completion are similar across services, whereas imperfect performance actually has a widely different impact on patients' health, due in part to the disparate probability of the occurrence of underlying conditions and disparate effectiveness of the CPS and treatments for the target condition.

Quality improvement interventions may require substantial time and resources. Physicians, patients, practice managers, and policymakers could all benefit from information on the impact of efforts to improve the use of CPS on actual illnesses or deaths prevented. Understanding the practical impact of CPS could enhance both physicians' ability to advise patients and patients' adherence to recommendations for CPS. The objectives of the study were to estimate the impact of CPS in preventing death and disease.

METHODS

Design and setting

This retrospective study analyzed the annual impact of evidence-based CPS recommended by the USPSTF for the prevention of cancer, cardiovascular disease, pneumonia and influenza, and osteoporosis for adults in the ambulatory setting. The primary independent variables were the annual proportion of patients in the practice who received the recommended CPS; the primary outcomes of interest were deaths *and* illness episodes *prevented.*

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Table 1. Clinical preventive services (CPS) quality of care indicators, eligibility, records sampled, and CPS received in the HealthTexas Provider Network*

Quality of care indicator by category	Eligibility: gender and age (years)	Records sampled (N)	CPS received (n)	CPS received (%)
Cancer				
Mammogram done 1 year prior to most recent visit	Women 50–75	1055	616	58.4
Pap smear done 3 years prior to most recent visit	Women 18–65	2206	1537	69.7
Colorectal cancer screening	≥50	2184	1243	56.9
Coronary heart disease and stroke				
Blood pressure measured on each visit 1 year prior to most recent visit	All patients	1826	1823	99.8
Total cholesterol done 5 years prior to most recent visit	Men 35–75 Women 45–75	2749	2366	86.1
LDL cholesterol done 5 years prior to most recent visit	Men 35–75 Women 45–75	2749	2350	85.5
Vaccine-preventable illness				
Flu vaccine done 1 year prior to most recent visit	≥65	910	515	56.6
Pneumococcal immunization done	≥65	916	692	75.5
Osteoporosis				
Bone mineral density measurement done	Women 65–80	434	300	69.1
Smoking-attributable mortality				
Tobacco use screening and counseling of documented tobacco users	All patients	576	449	78.0

*Thirty randomly selected charts per physician for patients aged 18 years or older were examined in quarterly audits to determine CPS delivery by HealthTexas Provider Network physicians (Baylor Health Care System, Dallas–Fort Worth, TX). For each sample, records were excluded from the CPS samples if the patient died, was admitted to a nursing home for custodial care, was transferred to hospice, moved out of the area, had no visit during the quarter, was a worker's compensation patient, or had a complex medical condition such as terminal cancer, stage 4 heart failure, or recent coronary artery bypass or similar condition documented by the provider that would generally preclude a CPS.

The study setting was the HealthTexas Provider Network (HTPN), the ambulatory care network affiliated with the Baylor Health Care System, a not-for-profit health care system in the Dallas–Fort Worth metropolitan area. In 2005 HTPN consisted of 49 practices with 260 primary care physicians. The number of HTPN patients aged 18 years or older eligible for CPS was estimated to be 245,000 using the annual number of visits by age and sex in the 18-month interval from January 1, 2004, through June 30, 2005 (5, 6). The number of patients eligible for specific CPS varies by age and gender *(Table 1).*

HTPN has a longstanding commitment to improving the delivery of CPS and has implemented a series of quality improvement interventions to increase the delivery of CPS (7). The HTPN Quality Committee monitors the use of USPSTF-recommended CPS in the HTPN practices through review of quarterly samples of 30 records for each physician. HTPN CPS samples for January 1 through June 30, 2005, were analyzed, and the analysis of the impact of CPS in HTPN was conducted in 2006 and modified in 2007.

Approach and conceptual framework

The analysis was performed from the perspective of an ambulatory practice responsible for the primary care of adults where physicians and managers use both the process measures of CPS provided to patients and information on deaths and illnesses prevented by CPS to set priorities for quality improvement interventions. A conceptual framework was developed for each category of preventable condition (cancer, cardiovascular disease, influenza and pneumonia, and osteoporosis) and an aggregate category of smoking-attributable deaths. Each preventable condition has one or more associated USPSTF-recommended CPS for specific age and gender groups based on risk of the preventable condition and the effectiveness of the CPS in the population at risk. For each preventable condition, preventable deaths and incident clinical episodes of illness or disease (such as pneumonia, myocardial infarction, or colorectal cancer) were identified.

Estimating expected clinical events

The annual mortality rate or incidence rate of each preventable condition was identified from the best available representative cohort studies or national surveys *(Table 2).* Separate mortality rates and incidence rates for each of the preventable conditions were calculated for a referent or comparison population that did not receive the CPS and a population that had received the CPS using condition-specific risk models (e.g., Framingham Heart Study) or by adjusting population incidence rates from national surveys by the proportion of the population that received the CPS (also obtained from national surveys) and the effectiveness of the CPS in reducing mortality or incidence of the condition.

The relative risks of death, incident disease, or a relevant clinical illness associated with the underlying preventable condition for each CPS were obtained from peer-reviewed randomized controlled trials of the recommended CPS when available; otherwise, the relative risks in cohort studies or odds ratios in case-control studies were used *(Table 3).* Relative protection, reported for cervical cancer screening (8), was converted to relative risk. When available, the 95% confidence intervals around the relative risks or odds ratios were used to estimate the precision of the clinical events prevented by each CPS in the HTPN population.

Table 2. Preventable conditions and preventable outcomes analysis: data sources and estimates used in analyses

Data sources	Data extracted or estimated
Cancer (breast, cervical, and colorectal cancer)	
HTPN CPS quality indicators	Population at risk; mammography, Pap test, and colorectal cancer screening tests done
SEER (9)	Breast, cervical, and colorectal cancer incidence and mortality in 13 SEER regions
DevCan (10)	Annual probability of incident cancer and cancer death
BRFSS (11)	Proportion of 13 SEER regions' population with cancer screening
CHD and stroke	
HTPN CPS quality indicators	Population at risk, blood pressure screening, and lipid screening
Framingham Heart Study (12)	Annual probability of CHD and stroke
NHANES (34)	Systolic blood pressure, total cholesterol, weight, and pharmaceutical treatment for hypertension and hyperlipidemia in the US population
Pneumonia and influenza	
HTPN CPS quality indicators	Population at risk, pneumonia vaccine done, influenza vaccine done
NHDS (35)	Annual probability of hospital admissions for pneumonia (ICD-9 code 481) and influenza (ICD-9 code 487.XX)
NAMCS (24); NHAMCS (25)	Annual probability of an ambulatory visit for pneumonia or influenza
Osteoporosis and fractures	
HTPN CPS quality indicators	Population at risk, bone mineral density screening done
NHDS (35)	Annual probability of hospital admissions for fracture of hip (ICD-9 code 820), vertebra (ICD-9 codes 805.2, 805.4, 806.2, and 806.4), or forearm (ICD-9 codes 813.4 and 813.5)
NAMCS (24); NHAMCS (25)	Annual probability of an ambulatory visit for fracture of hip, vertebra, or forearm
Smoking-attributable mortality	
HTPN CPS quality indicators	Population at risk, tobacco use, and tobacco use counseling
CPS II	Relative risk of smoking-attributable mortality for 19 conditions
SAMMEC (30)	Annual number of smoking-attributable deaths

BRFSS indicates Behavioral Risk Factor Surveillance System; CHD, coronary heart disease (i.e., angina, coronary insufficiency, myocardial infarction, sudden death); CPS, clinical preventive services; CPS II, Cancer Prevention Study II; DevCan, Probability of Developing or Dying of Cancer Software; HTPN, Health-Texas Provider Network; NAMCS, National Ambulatory Medical Care Survey; NHAMCS, National Hospital Ambulatory Medical Care Survey; NHANES, National Health and Nutrition Examination Survey; NHDS, National Hospital Discharge Survey; SAMMEC, Smoking-Attributable Mortality, Morbidity, and Economic Costs Software; SEER, Surveillance, Epidemiology, and End Results Program.

Clinical events prevented by clinical preventive services

The number of events expected in the HTPN population was calculated using the number of persons in HTPN for which the CPS was recommended, the proportion of the HTPN population that received the CPS, the difference in the clinical events (deaths or incident illness episodes) expected in the HTPN patients that did not receive CPS, and the clinical events expected in the HTPN population that received CPS. Calculations were performed using rates and proportions stratified by sex and decade of age.

Clinical preventive services for cancer

The annual risk of developing or dying of breast cancer, cervical cancer, or colorectal cancer for 2000–2002 was obtained from the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) program (9) using the Probability of Developing or Dying of Cancer Software program (10). The upper age limit in this software is 85 years; the incidence and mortality rates for persons older than age 85 were assumed to be the same as those for persons age 85. We used the Behavioral Risk Factor Surveillance System screening rate for the recommended cancer screening preventive services, restricted to the 13 SEER regions, as estimates of the proportion of the SEER population that received each recommended CPS (11). These estimates and the medical literature-reported relative risk of incidence of cancer or cancer mortality for a screened population were used to estimate the incidence and mortality rates of each cancer in a population that received the recommended CPS for cancer screening and a population that did not receive any of the recommended CPS for cancer screening.

Clinical preventive services for coronary heart disease and stroke

The Framingham Heart Study models of coronary heart disease (CHD) events (angina pectoris, coronary insufficiency, myocardial infarction, or sudden death) and stroke (atherothrombotic brain infarction) were used to evaluate the impact of office-based blood pressure screening (and treatment of detected hypertension) and lipid screening (and treatment of detected hyperlipidemia) in the ambulatory setting (12). The Framingham Heart Study models use age, sex, systolic blood pressure, total cholesterol, Metropolitan relative weight (13), and cigarette smoking as independent predictors of the risk of CHD, sudden death, or stroke. Age, sex, and smoking status were directly available from the HTPN CPS quality improvement program, but the blood pressure and lipid measurements were not routinely collected with CPS performance indicators. Assuming that the ambulatory patients in the HTPN practices were similar to the general US population, we used the US National Health and Nutrition Examination Survey to estimate the systolic blood pressure, prevalence of diagnosed hypertension, proportion of patients with hypertension who are treated with medications, total cholesterol level, prevalence of diagnosed hyperlipidemia, proportion of patients with

Table 3. Effectiveness of clinical preventive services

Preventive service	Recommendations	Data source	Outcome	Effectiveness: RR (95% CI)
Mammography	USPSTF (36)	Meta-analysis (37)	Breast cancer death	0.78 (0.70–0.87)
Pap test	USPSTF (38)	Cohort studies and national surveys (8)	Incident cancer	0.12 (0.05–0.29)
			Cervical cancer death	0.12 (0.05–0.29)
CRC screening	USPSTF (39, 40)			
Colonoscopy		Case-control study (41)	Incident cancer	0.47 (0.37–0.58)
		Case-control study (42)	CRC death	0.43 (0.30–0.63)
Sigmoidoscopy		Case-control study (41)	Incident cancer	0.56 (0.46–0.67)
		Case-control study (43)	CRC death	0.41 (0.25–0.69)
Barium colonography		Review (44–46)	Incident cancer	0.62 (0.54–0.70)
			CRC death	0.66 (0.50–0.76)
Fecal occult blood test		Randomized controlled trials (47, 48)	Incident cancer	0.83 (0.73–0.94)
			CRC death	0.79 (0.62–0.97)
Blood pressure screening	USPSTF (15, 49)	Meta-analysis (14)	CHD	0.74 (0.67–0.81)*
			Sudden death	0.37 (0.26–0.48)*
			Stroke	0.57 (0.47–0.63)*
Lipids screening	USPSTF (17, 50)	Meta-analysis (15)	CHD	0.37 (0.26–0.48)†
			Sudden death	0.29 (0.19–0.41)†
Pneumococcal vaccine	ACIP (22)	Meta-analysis (51)	Hospital admission	0.47 (0.35–0.63)
			Ambulatory visit	0.47 (0.35–0.63)
Influenza vaccine	ACIP (16–21)	Review (52)	Hospital admission	0.55 (0.36–0.85)
			Ambulatory visit	0.55 (0.36–0.63)
Bone mineral density testing	USPSTF (26, 27, 53)	Meta-analysis (54)	Hip fracture	0.63 (0.43–0.92)
			Vertebral fracture	0.52 (0.43–0.65)
			Forearm fracture	0.48 (0.29–0.78)
Tobacco use screening and counseling	USPSTF (28, 29)	Meta-analysis (55)	Smoking cessation	0.90 (0.87–0.93)‡

*Men aged 55 to 59 with a 14 mm Hg (95% CI 10.5–18.2) reduction in systolic blood pressure (14) using Framingham Heart Study risk model (12). RR varies by age and sex strata.

†Men aged 55 to 59 with a 27% (95% CI 21%–34%) reduction in total cholesterol (15) using Framingham Heart Study risk model (12). RR varies by age and sex strata.

‡Relative risk, assuming a 50% relapse at 12 months from the 6-month smoking cessation of 19.9% (95% CI 13.7–26.2) (55).

ACIP indicates Advisory Committee on Immunization Practices; CHD, coronary heart disease; CI, confidence interval; CRC, colorectal cancer; RR, relative risk; USPSTF, US Preventive Services Task Force.

hypercholesterolemia who are treated with medications, and the Metropolitan relative weight in the HTPN population. These estimates and the prevalence of smoking in the HTPN population were used to estimate the annual probability of CHD, sudden death, and stroke in populations without office blood pressure screening and treatment or lipid screening and treatment. We used literature estimates of the effectiveness of drug treatment for hypertension (14) and hyperlipidemia (15) to estimate the reduction in risk of CHD, sudden death, and stroke in populations with office blood pressure screening and treatment of hypertension or with lipid screening and treatment of hyperlipidemia.

Clinical preventive services for influenza and pneumonia

An annual influenza vaccine (16–21) and one-time pneumococcal pneumonia vaccine (22) are recommended for all adults aged 65 or older. The preventable clinical outcomes associated with pneumococcal disease and influenza were hospital admission and ambulatory visits. The National Hospital Discharge Survey (23) was used to estimate hospital admission rates for pneumococcal pneumonia or influenza. The National Ambulatory Medical Care Survey (24) and National Hospital Ambulatory Medical Care Survey (25) were used to estimate physician office and hospital clinic utilization rates for pneumonia and influenza.

Clinical preventive services for prevention of osteoporosis-related fractures

Routine screening for osteoporosis is recommended for women aged 65 or older (26, 27). Osteoporosis screening and treatment with vitamin D, calcium, and bisphosphonates is effective in preventing osteoporosis fractures (26, 27). The osteoporosis screening outcomes included in our analysis were hospital admissions for fractures of vertebral bodies, hip, or forearm. We used the National Hospital Discharge Survey to estimate the decade of age and sex-specific incidence of hospital admission for fractures of the hip, vertebral bodies, and forearm.

Clinical preventive services for smoking-attributable mortality

Routine tobacco use screening and counseling of current tobacco users is recommended for all adults (28, 29). The CDC has developed a method for estimating smoking-attributable mortality and the economic consequences of smoking, as well as an online software system, Smoking-Attributable Mortality, Morbidity, and Economic Costs (SAMMEC), to facilitate and standardize these estimates on a state basis (30). SAMMEC uses the prevalence of current and former smokers and number of deaths due to malignant neoplasm, cardiovascular disease, and respiratory disease (a total of 19 conditions) to estimate the number

Table 4. Clinical preventive services and outcomes prevented in the HealthTexas Provider Network, 2005

Preventive service	Eligible group: gender and age	Eligible population (N)	Received (%)	Preventable outcome	Outcomes prevented: N (95% CI)
Mammography	Women 50–75	48,292	58.4	Breast cancer death	5 (2–6)
Pap test	Women 18–65	125,415	69.7	Incident cancer	45 (21–69)
				Cervical cancer death	10 (5–16)
Any CRC test*	Age ≥50	101,953	56.9	Incident cancer	52 (39–64)
				CRC death	21 (11–27)
Blood pressure	All patients	141,404‡	99.8	Coronary heart disease†	133 (99–166)
				Sudden death	24 (18–29)
				Stroke	118 (90–143)
Total cholesterol	Men 35–75 Women 45–75	141,404	86.1	Coronary heart disease†	287 (232–343)
				Sudden death	42 (35–50)
Pneumococcal vaccine	Age ≥65	42,603	75.5	Hospital admission	13 (8–20)
				Ambulatory visit	60 (39–93)
Influenza vaccine	Age ≥65	42,603	56.6	Hospital admission	11 (8–14)
				Ambulatory visit	756 (563–1013)
Bone mineral density	Women 65–80	21,005	69.1	Hip fracture	70 (48–102)
				Vertebral fracture	12 (10–15)
				Forearm fracture	6 (4–10)
				Total fractures¶	87 (61–126)
Tobacco use counseling	Age ≥18	245,525	78.0	Tobacco use cessation	2750 (1893–3621)
Tobacco use counseling	Age ≥35	181,680	79.7	Death	19

*A hierarchy of effectiveness of colorectal cancer (CRC) screening recommendations was established with four levels: 1) colonoscopy, 2) flexible sigmoidoscopy and home fecal occult blood test (FOBT), 3) double-contrast barium enema and home FOBT, and 4) home FOBT. Patients who had more than one method for CRC screening were classified by highest level of CRC screening documented.

†Includes myocardial infarction, coronary insufficiency, and sudden death, but not stroke.

‡Analysis for CHD events and stroke prevented using Framingham Heart Study (12) was restricted to the population eligible for both blood pressure measurements and lipid screening.

¶Total fractures prevented differs from the sum of individual fracture estimates due to rounding.

of smoking-attributable deaths in adults aged 35 or older in a state. We used the prevalence of smoking in the HTPN population and assumed that the prevalence of current and past smokers in the US population was similar to the ratio of current and past smokers in the HTPN population. We used the 2002 Texas mortality data and SAMMEC to estimate the number of deaths expected in the HTPN population. We estimated the number of HTPN patients who were new quitters each year using the prevalence of current tobacco use and the effectiveness of physician office–based counseling in maintaining abstinence from smoking at 1 year. The number of smoking-attributable deaths prevented was estimated as the difference in a population with baseline prevalence of smoking and the lower prevalence resulting from office-based counseling of smokers.

RESULTS

The impact of each CPS in the HTPN practices on deaths and illness episodes prevented in 2005 is summarized in *Table 4*. A mammogram for breast cancer screening was performed in 58.4% of the 48,292 women aged 50 to 75. Breast cancer screening was estimated to have prevented 5 breast cancer deaths. A Pap test for cervical cancer screening was obtained in the previous 3 years for 69.7% of women aged 18 to 65. Cervical cancer screening was estimated to have prevented 45 incident cases and 10 cervical cancer deaths. Colorectal cancer screening using at least one of the recommended screening tests for colorectal cancer was performed in 56.9% of the 101,953 eligible men and women aged 50 or older. Colorectal cancer screening was estimated to have prevented 52 incident cases and 21 colorectal cancer deaths.

Office blood pressure was obtained for 99.8% of the office visits and total cholesterol was measured within the previous 5 years for 86.1% of the 141,404 eligible men aged 35 or older and women aged 45 or older who had an office visit. Routine measurement of blood pressure during office visits with increased identification and treatment of hypertension was estimated to prevent 133 CHD events (including 24 sudden deaths) and 118 strokes in the HTPN population. Lipid screening with increased identification and treatment of hyperlipidemia was estimated to prevent 287 CHD events, including 42 sudden deaths.

Influenza vaccine was documented in 56.6% of the 42,603 HTPN patients aged 65 or older and was estimated to have prevented 756 influenza episodes that would have required an office visit and 11 influenza hospital admissions. Seventy-six percent of adults aged 65 or older had received the pneumococcal vaccine. Pneumococcal pneumonia vaccination was estimated to have prevented 60 pneumococcal pneumonia episodes requiring ambulatory treatment and 13 hospital admissions.

Bone mineral density screening for osteoporosis was documented in 69.1% of the 21,005 women aged 65 to 80. Osteoporosis screening and treatment was estimated to have prevented 70 hip fractures, 12 vertebral fractures, and 6 wrist fractures that would have required hospital admission.

In 2005, an estimated 33,882 (13.8%) of 245,525 HTPN patients aged 18 or older reported tobacco use. Seventy-eight percent of these patients were counseled about tobacco use, and an estimated 2750 adults discontinued smoking and were nonsmokers 12 months later. Among the 181,680 HTPN patients aged 35 or older, an estimated 23,981 (13.2%) reported tobacco use, and 79.7% were counseled about tobacco use. In the 181,680 HTPN patients aged 35 or older, 19 smoking-attributable deaths were estimated to have been prevented.

DISCUSSION

This study used indicators of the performance of CPS in a large network of ambulatory practices to estimate the annual impact in terms of the prevention of deaths and clinical episodes of illness and disease. The CPS included screening for breast cancer, cervical cancer, and colorectal cancer; blood pressure and lipid screening for CHD and stroke; immunizations for pneumonia and influenza; screening for osteoporosis; and tobacco use screening and counseling. CPS for CHD and stroke have the largest impact on preventable deaths; CPS for CHD and cancer have a large impact on hospital admissions for preventable illness; and an annual influenza vaccine has a large impact on reducing ambulatory visits.

Our study had several strengths. First, it was a comprehensive analysis of the impact of evidence-based recommendations for CPS in the ambulatory setting. Second, our method identified incident episodes of acute illness (pneumonia, influenza), chronic disease (cancer, CHD, stroke, fracture), and death that are readily understood by patients, practice managers, and the public. Third, our study focused on a core set of evidence-based recommendations supported by the USPSTF and the ACIP. Fourth, we used performance indicators for the delivery of CPS as the major independent variable that must be directly measured from the clinical practice. Performance indicators for the delivery of CPS are now being adopted as measures of quality of ambulatory care and can be assessed from direct review of a sample of patient records, electronic administrative data or billing data, or electronic health records. Fifth, we used peer-reviewed medical literature estimates of the effectiveness of CPS. Sixth, we used population-based estimates, national surveys, and surveillance programs to estimate the risk of underlying conditions (pneumonia, influenza, fractures) and unmeasured risk factors in the population. Seventh, we adopted methods from the Framingham Heart Study to estimate the risk of CHD, sudden death, and stroke and methods adopted by the CDC in estimating smoking-attributable mortality.

Our study had several limitations inherent to any study that must synthesize information available from disparate sources. First, there was some overlap in our outcomes. For example, the Framingham Heart Study definition of CHD events includes angina, coronary insufficiency, myocardial infarction, and sudden death. We used a separate predictor from the Framingham Heart Study to identify sudden deaths prevented. Unfortunately, the Framingham Heart Study does not specifically predict the risk of *fatal* myocardial infarction, and thus our estimate of sudden deaths prevented, a subset of the CHD events that were prevented, may underestimate CHD deaths prevented. The CDC methodology for smoking-attributable mortality includes deaths for 19 smoking-attributable causes (10 categories of malignant neoplasia, 6 categories of cardiovascular disease, and 3 categories of respiratory disease) (30). There is some overlap in the smoking-attributable deaths and the separate estimates of deaths from cervical cancer, ischemic heart disease, and cerebrovascular disease. A second limitation of our study was its different methodological approaches by category of underlying condition for CPS. This was a consequence of our decision to use the strongest methods, best quality data, and accepted state-of-the-art approaches for cancer, cardiovascular disease, vaccine-preventable disease, smoking-attributable disease, and osteoporosis. A third limitation is that our approach underestimated the impact of CPS because only some measures of risk relied on associated use of ambulatory or hospital services. Fourth, our estimates of risk of pneumonia, influenza, and osteoporosis-related hospital admission did not permit precise estimates of risk of death during these admissions. A fifth limitation of our study was the use of population-based data and data from national surveys for data not directly available from the HTPN patients. Selection bias may have occurred in that the patients in the HTPN practice may have differed in unmeasured but important ways from the underlying population. Patients with access to care may have lower risk of preventable disease and higher adherence to recommended CPS than the general population, and thus we may have overestimated the impact of CPS in the HTPN practices. A sixth limitation is that our analysis assumed a stable population of patients who were under the care of primary care physicians and who received continuing care with periodic health evaluations and opportunistic screening. Estimates of the effectiveness of CPS from randomized controlled trials and cohort studies have been based on populations that have had multiple opportunities to benefit from CPS over several years. Finally, new CPS, such as human papillomavirus immunization to prevent cervical cancer, new screening tests for colorectal cancer or osteoporosis, and new medications or treatments for hypertension, hyperlipidemia, and osteoporosis may further increase the beneficial impact of CPS in the ambulatory setting.

The shortage of primary care physicians, constrained resources and payment for CPS, and limited time for CPS in the ambulatory setting require physicians, practice managers, and policymakers to set priorities for CPS. The National Commission on Prevention Priorities (NCPP) has initiated a comprehensive series of studies to set priorities for clinicians, employers, payers, and policymakers for CPS (31–33). A recent study from the NCPP evaluated 21 CPS recommended by the USPSTF and the ACIP (33). The NCPP method assigns scores to recommended CPS on a 1 to 10 scale (32). The method focuses on a US birth cohort of approximately 4 million and for each CPS evaluates the clinically preventable burden of disease (CPB) measured as quality-adjusted life years (QALYs) and the cost-effectiveness (CE) measured as costs per QALY gained from offering each CPS at the recommended intervals over the years of life for which the service is recommended. The use of QALYs thus includes measures of morbidity and mortality. The integer

Table 5. Setting priorities for clinical preventive services: comparison of National Commission on Prevention Priorities clinically preventable burden score and cost effectiveness score and clinical events prevented in HealthTexas Provider Network Practices, 2005

	NCPP analysis			HTPN practices, 2005	
Preventive service	CPB score	CE score	Total score	Outcome	Events prevented per year
Mammography	4	2	6	Breast cancer death	5
Pap test	4	3	7	Incident cancer Cervical cancer death	45 10
CRC screening	4	4	8	Incident cancer CRC death	52 21
BP screening	5	3	8	CHD event Sudden death Stroke	133 24 118
Cholesterol screening	5	2	7	CHD event Sudden death	287 42
Pneumonia vaccine	3	5	8	Incident case Hospital admission	60 13
Influenza vaccine	4	4	8	Incident case Hospital admission	756 11
Osteoporosis	2	2	4	Fracture	87
Tobacco use screening and counseling	5	5	10	Smoking-attributable death	19

BP indicates blood pressure; CE, cost-effectiveness; CPB, clinically preventable burden score; CRC, colorectal cancer; HTPN, HealthTexas Provider Network, NCPP, National Commission on Prevention Priorities.

scores are assigned to quintiles of CPB and CE, and the final score is the sum of equally weighted CPB and CE. In contrast to the longitudinal cohort approach of the NCPP methodology, our cross-sectional approach looks at the impact of each CPS in a population of approximately 250,000 adults in primary care practice. Our approach uses clinical events such as deaths and illness episodes rather than metrics such as number needed to screen, QALYs, or a summary score.

Table 5 summarizes the NCPP scores for CPB and CE for each CPS over the course of the lifetime for a US birth cohort and our cross-sectional analysis of the impact of each CPS on clinical events prevented. The NCPP ranks tobacco use screening and tobacco use counseling highest, with a score of 10. The HTPN estimate is 19 smoking-attributable deaths prevented each year from tobacco use screening and tobacco use counseling. For cancer, the NCPP ranks screening for colorectal cancer as 8, cervical cancer as 7, and breast cancer as 6. The HTPN estimates are similar in rank order, but the HTPN estimate indicates a larger impact of colorectal cancer screening (21 deaths prevented each year) and cervical cancer screening (10 deaths prevented each year) than breast cancer screening (5 deaths prevented each year). The larger impact of cervical cancer screening is due to the larger size of the population at risk due to wide age range (18 to 65), and the larger impact of colorectal cancer is due to inclusion of both men and women aged ≥50, compared with breast cancer screening of women aged 50 to 75. For CHD, the NCPP ranks blood pressure screening as a score of 8 and lipid screening as a score of 7. In the HTPN study, the impact of lipid screening (287 CHD events prevented each year) is greater than the impact of blood pressure screening (133 CHD events and 118 strokes prevented each year). For vaccine-preventable disease, the NCPP ranks both pneumonia and influenza vaccine with a score of 8. The HTPN estimate for the impact of annual influenza vaccine (756 cases prevented each year) is greater than the impact of pneumonia vaccine (60 cases of pneumonia prevented each year). The NCPP score for osteoporosis screening is only 4. The HTPN estimate suggests greater benefit, with an estimate of 87 fractures prevented each year.

The current study confirms that there are substantial benefits from CPS and quantifies the impact of quality improvement interventions to measure and improve the delivery of CPS (7). The CPS studied are high priority for health care providers as judged by the large numbers of deaths and clinical events prevented. Although quality improvement efforts for CPS typically focus on process measures such as the proportion of eligible patients who have received the CPS, our study confirms that there is a substantial impact in the ambulatory population. The deaths and illness episodes prevented are not directly observed by clinicians, are not experienced by patients, and are not directly evident to practice managers and policymakers (prevention paradox). Our study quantifies the annual magnitude of these averted illnesses and deaths and thereby provides valuable evidence to assist patients, physicians, practice managers, and policymakers in making decisions about CPS. Patients may be motivated by this information to accept their physicians' recommendations for immunizations, screening tests, medications, and changes in lifestyle. Physicians can use this information to set priorities for allocating time for CPS. Practice managers can use this information to provide resources to support the delivery of CPS and set priorities for quality improvement programs. Policymakers and payers can use these data in making decisions about insurance coverage for CPS.

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