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ORIGINAL RESEARCH & CONTRIBUTIONS

Identifying Opportunities for a Medical Group to Improve Outcomes for Patients with Coronary Artery Disease and Heart Failure: An Exploratory Study

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Abstract

Context: A decision-support tool was created to identify opportunities to improve outcomes for patients with coronary artery disease and heart failure by delivering all efficacious interventions; that is, "optimizing" care. When national data were applied, nearly 75% of the deaths that could be prevented or postponed by optimizing care for patients with heart disease would occur among ambulatory patients.

Objective: The purpose of this analysis is two-fold: 1) to determine whether medical group data are adequate to use in the decision-support tool, and 2) to determine whether the conclusions generated from the medical group data are similar to the conclusions generated from US data.

Design/Main Outcome Measure: The potential impact of optimizing care for patients age 40 to 75 years treated for coronary artery disease and heart failure by a multispecialty group between August 2007 and July 2008 was calculated using deaths that might be prevented or postponed if optimal care was achieved.

Results: The greatest opportunity to prevent or postpone deaths—70% of the total opportunity—lies with optimizing care for ambulatory patients. Optimizing care for patients hospitalized for acute myocardial infarction with or without ST-segment elevation on electrocardiography would prevent or postpone only 2% of deaths.

Conclusions: This study demonstrates that 1) it is feasible to use the decision-support tool to analyze opportunities for improvement in a medical group, and 2) as concluded from national data analysis, optimizing ambulatory care presents the greatest opportunity to improve outcomes for patients with heart disease.

Introduction

Epidemiologic observations, clinical trials, and sophisticated analytic techniques have all led to an understanding that a significant portion of heart disease might be prevented for those who do not yet have the disease and recurrent events could be prevented for patients who have already suffered a cardiac event. To help policymakers and clinicians identify opportunities to improve outcomes for patients who have or are at risk for heart disease, we created a decision-support tool that estimates the number of deaths that could be prevented or postponed (DPP) if all efficacious services were delivered for the prevention and treatment of coronary artery disease (CAD) and heart failure (HF); that is, if care were optimized.[1] Despite the fact that heart disease is a leading killer of Americans,[2] no transparent, unbiased method has been available to calculate the comparative effectiveness of heart disease prevention and treatment interventions. The ability to compare the effectiveness of different strategies has the potential to increase the effectiveness and value of public health campaigns and clinical care improvement initiatives.

When an individual has an event that leads to the diagnosis of CAD or HF, it occurs in one of three scenarios: 1) an out-of-hospital cardiac arrest; 2) hospitalization for an acute event characterized by symptoms such as chest pain, dyspnea, or syncope; or 3) initial diagnosis made in the ambulatory setting because of symptoms or a routine examination. The decision-support tool divides the ambulatory population into three prevalence pools of individuals with: 1) no apparent heart disease, 2) symptomatic heart disease with a left ventricular ejection fraction (LVEF) >35%, and 3) symptomatic heart disease and a LVEF ≤35% (Figure 1).

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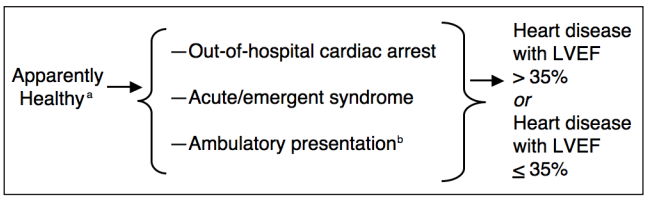
This analysis focuses on the scenarios in which patients with CAD and/or HF are treated by clinicians in the hospital and in the ambulatory setting. We chose not to include out-of-hospital cardiac arrest because treatment relies on the organization of emergency medical services rather than hospital or ambulatory services. We also chose not to address primary prevention because we did not have robust data on levels of physical activity and nutrition for our population.

The analysis addresses two questions: 1) are sufficient data available in a "real" medical group to use the decision-support tool?, and 2) are the results obtained from the analysis of medical group data similar to those generated from US data?



[a] includes occult CAD

[b] includes incidentally discovered CAD

CAD = coronary artery disease; LVEF = left ventricular ejection fraction

Figure 1. Conceptual model of heart disease used in the analysis. Members of the population reside in one of three prevalence pools. All clinical events are classified as one of three types. The analysis focuses on the treatment of patients who have been diagnosed with heart disease, hospitalized with acute and/or emergent syndromes, or newly diagnosed in the ambulatory setting.

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Methods

The target population for this study was the HealthPartners Medical Group in Minneapolis, MN. All data related to clinical care were abstracted from the HealthPartners electronic medical record. Data related to acute events (hospitalizations) was based on Regions Hospital data. Regions Hospital is the main hospital affiliated with HealthPartners, however it is important to note that not all HealthPartners patients were hospitalized at Regions Hospital. Mortality rates were based on analysis of the HealthPartners insured population. This study was approved by the HealthPartners institutional review board as protocol 08-093.

Case Definitions

Cases were defined as those meeting at least one of six scenarios with at least one International Statistical Classification of Diseases and Related Health Problems, 9th Revision Clinical Modification (ICD-9-CM) diagnostic code in the range of 410 to 414 or 420 to 429. Diagnoses were assigned using the following hierarchy: hospitalized for ST-segment elevation myocardial infarction (STEMI) on electrocardiogram (ECG); hospitalized with acute HF and an LVEF ≤35%; hospitalized for non-ST-segment elevation myocardial infarction (nSTEMI) on ECG; hospitalized for unstable angina pectoris (UA); initial diagnosis of CAD and/or HF in the ambulatory setting without hospitalization; and chronic, prevalent heart disease. The period of observation was August 8, 2007 (the date that HealthPartners' inpatient and outpatient ECG files were merged into a single file) to July 31, 2008. Records for patients who had not been hospitalized during this period were also examined for ICD-9-CM diagnostic codes 410 to 414 or 420 to 429 for August 8, 2005 to August 7, 2007 to determine whether they had been diagnosed with heart disease before August 8, 2007 and thus would be considered to have chronic prevalent disease rather than heart disease newly diagnosed in the ambulatory setting.

Confirming the Cases

To characterize the medical care received by patients in each of the six categories, randomly selected *candidate* patients were reviewed until at least 30 *confirmed* patients in each category were identified. The medical record of each candidate patient was reviewed to confirm the diagnosis. Demographic and treatment data were abstracted on confirmation. Hospitalized patients with an ICD-9-CM diagnostic code of 410.0 to 410.9 or an elevated troponin level plus text in the medical record consistent with acute myocardial infarction (MI) were classified as STEMI or nSTEMI, depending on the ECG patterns. Hospitalized patients with an ICD-9-CM diagnostic code of 425 or 428 with an LVEF ≤35% and a clinical history consistent with acute HF were categorized as HF. Patients with ICD-9-CM discharge codes of 410 to 414, 420 to 424, 426, 427, or 429 and normal troponin values (or no troponin measurements) were categorized as UA if their clinical presentation was consistent with the diagnosis.

Any patient having a clinical visit between August 8, 2007 and July 31, 2008 with ICD-9-CM codes 410 to 414 or 420 to 429 but no record of hospitalization for heart disease during that period and no clinic visits with heart disease codes between August 8, 2005 and August 7, 2007 were considered to have heart disease newly diagnosed in the ambulatory setting. Patients meeting the same criteria with the exception of having a heart disease code assigned

… no transparent, unbiased method has been available to calculate the comparative effectiveness of heart disease prevention and treatment interventions.

Table 1. Demographic attributes of HealthPartners Medical Group and Regions Hospital patients with coronary artery disease or heart failure (n = 13,805)

Attribute	Mean or percentage (95% confidence interval)
Age	60.9 (60.1, 61.7)
Male	59.2% (58.4, 60.0)
Race	
White	71.4% (70.6, 72.2)
African American	7.4% (7.0, 7.8)
Other	4.2% (3.9, 4.5)
Unknown	17.0% (16.4, 17.6)
Hypertension	57.0% (56.2, 57.8)
Hyperlipidemia	57.0% (56.2, 57.8)
Body mass index	
≤25	9.7% (9.2, 10.2)
>25	73.1% (72.4, 73.8)
Unknown	17.2% (16.6, 17.8)
Current Smoker	
No	53.0% (52.2, 53.8)
Yes	10.4% (9.9, 10.9)
Unknown	36.6% (35.8, 37.4)
Serum creatinine	1.12 (1.11, 1.13)
Left ventricular ejection fraction >35%	92.4% (89.9, 94.6)[a]

[a] Of 565 ambulatory patients who had an echocardiogram between August 8, 2007 and July 31, 2008.

to a hospitalization or a clinic visit during August 8, 2005 to August 7, 2007 were considered to have chronic prevalent heart disease.

Calculating Event, Case-Fatality, and Mortality Rates

Not all patients treated at Regions Hospital are members of HealthPartners, and only a minority of members of HealthPartners treated for an acute cardiac event are hospitalized at Regions Hospital. That is because when a patient has an acute event, they often go to the nearest hospital regardless of affiliation with the insurance company. To overcome this limitation, we used the experiences of all HealthPartners members (the Medical Group of interest) between August 8, 2007 to July 31, 2008 to estimate event rates and help overcome this limitation.

At the time of data abstraction, the most recently available death certificate data were from 2007. Therefore, the case-fatality rate for each type of acute event and for the entire population with CAD and/or HF was calculated from HealthPartners membership for August 8, 2005 to December 31, 2007. The data from all HealthPartners members during this period were used to minimize the error of the estimate and generate rates from a defined population.

Ascertainment of Left Ventricular Ejection Fraction in the Cohort with Chronic Prevalent Disease

To estimate the prevalence of chronic heart disease associated with an LVEF ≤35%, the records of all patients who met the criteria for chronic prevalent disease were reviewed for August 8, 2007 to July 31, 2008. This period was selected because the LVEF was automatically entered into a data field in the medical record starting in August 2007. The analysis is based on 565 ambulatory patients.

Estimating the Ratio of STEMI to nSTEMI Cases

The ICD-9-CM diagnostic codes for MI in the medical records did not accurately distinguish between STEMI and nSTEMI cases. Therefore, the ratio of STEMI to nSTEMI cases was estimated from the validated cases of acute MI. Thirty-two of the randomly selected cases with an ICD-9-CM 410.x discharge code were STEMI cases; 26 were nSTEMI. Six additional nSTEMI cases were identified because of elevated troponin values and a history consistent with acute MI without an ICD-9-CM 410.x discharge code. The ratio of STEMI to nSTEMI cases was considered 1:1.

Estimating Physical Activity Levels

We did not have adequate data in the Medical Group to estimate physical activity levels. Because these data were lacking, we assumed that the average physical activity level for patients in our analysis was the same as the US average for patients with heart disease. The US average physical activity level for patients with heart disease was based on the American Heart Association Heart and Stroke Statistics from 2007.[2] Regular leisure-time physical activity was defined as ≥ 30 minutes ≥ 5 days a week or vigorous activity ≥ 20 minutes ≥ 3 times a week.[3] Adequate levels of physical activity varied from 19% to 33% depending on the age, sex, and ethnicity, 33% was used for this analysis, as it results in the least overestimation of impact if physical activity levels were to be optimized.

The analysis used the cumulative relative-benefit approach of Mant and Hicks to calculate the joint effect of simultaneous interventions.[4] The results were not discounted because discounting biases against future generations.

Sensitivity Analysis

To test the sensitivity of the conclusions, upper-bound estimates and lower-bound estimates were created as ±20% of the observed values (plausible ranges). This range was selected to allow for a lower confidence in the accuracy of the observed data and estimates.

Results

During the period of observation, 13,805 patients of HealthPartners Medical Group or Regions Hospital ages 40 to 75 years had either prevalent CAD and/or HF or experienced an acute CAD and/or HF event. The average age was just over 60 years, and just less than 60% were men (Table 1). More than half of those with CAD and/or HF also had hypertension and hyperlipidemia. More than two-thirds of the group was overweight or obese. More than 90% of the members with CAD and/or HF had an LVEF >35%.

The prevalence of CAD and/or HF in the HealthPartners population ages 40 to 75 years was 9646/100,000; the number of deaths from any cause among members with a diagnosis of CAD and/or HF was 104/100,000 (plausible range, 67 to 150). Despite the death rate for the members with an LVEF ≤35% of about four times greater than the death rate for members with an LVEF >35%, most deaths occurred among members who had an LVEF >35% (Table 2).

The rate of acute CAD and/or HF events was 3226 per 100,000 adults ages 40 to 75 years (Table 3). About 3% of the events were STEMIs; about 4% were because of HF with an LVEF ≤35%; 3% were nSTEMIs; and more than 20% were because of UA. Nearly 70% of acute events were CAD and/or HF newly diagnosed in the ambulatory setting. One-year fatality rates differed by a factor of 10 from 0.013 for patients with heart disease newly diagnosed in the ambulatory setting to 0.137 for patients hospitalized for HF with an LVEF ≤35%.

Acute events were followed by 72 deaths per year per 100,000 adults ages 40 to 75 years. The largest number of deaths followed a new diagnosis of heart disease in the ambulatory setting. The second largest number of deaths followed hospitalization for HF with an LVEF ≤35%. Less than 10% of the deaths followed hospitalization for STEMI. The same was true for hospitalization for nSTEMI.

Potential Impact of Increasing Specific Interventions

The outcome of interest used in this analysis, DPP, is an accepted outcome that has been used to estimate the source of the change in deaths from heart disease

Table 2. Population pools, death rates, and number of deaths at current levels of treatment per 100,000 members of HealthPartners ages 40 to 75 years

Population pool	Pool size (plausible range)[a]	All-cause death rate (plausible range)[a]	Annuals deaths per 100,000 adult members ages 40 to 75 years (plausible range)[a]
Heart disease with LVEF >35%	8874 (7099 – 10,649)	0.0088 (0.0070 – 0.0106)	78 (50 – 112)
Heart disease with LVEF ≤35%	772 (618 – 926)	0.341 (0.0273 – 0.0410)	26 (17 – 38)

[a] The plausible range is defined as ±20% of the observed value.
LVEF = left ventricular ejection fraction

Table 3. Annual number of events, one-year fatality rates and number of deaths per 100,000 members of HealthPartners ages 40 to 75 years by type of heart disease event

Clinical event	No. of events (plausible range) [a]	One-year fatality rate (plausible range)[a]	Annual number of deaths per 100,000 members ages 40 to 75 (plausible range)[a]
STEMI	112 (90 – 134)	0.042 (0.034 – 0.050)[b]	5 (3 – 7)
Acute heart failure with LVEF ≤35%	130 (104 – 156)	0.137 (0.110 – 0.164)	18 (11 – 26)
nSTEMI	112 (90 – 134)	0.042 (0.034 – 0.050)[b]	5 (3 – 7)
Unstable angina/other heart disease	690 (552 – 828)	0.024 (0.019 – 0.029)	16 (11 – 24)
Heart disease newly diagnosed in the ambulatory setting	2182 (1746 – 2618)	0.013 (0.010 – 0.016)	28 (18 – 41)

[a] Ranges are "plausible" estimates defined as ±20% of the observed value.
[b] One-year fatality rates for STEMI and nSTEMI are assumed to be the same. Electrocardiograms were not available for review, and ICD-9-CM coding did not adequately discriminate between STEMI and nSTEMI.
LVEF = left ventricular ejection fraction; nSTEMI = myocardial infarction without ST-segment elevation; STEMI – ST-segment elevation myocardial infarction

in the US and several other countries.[5-9] The number of DPP with optimal care was calculated as follows:

DPPoptimal care = (expected mortality reduction when the intervention is implemented) X (mortality) X (1 - current implementation rate[1]) X (number in the population).

Prevalence pools: The potential to increase the DPP by optimizing care for patients with prevalent CAD and/or HF and an LVEF >35% would be 31.9 deaths (plausible range, 8.1 to 82.3) (Table 4). Nearly 90% of these patients were taking aspirin and beta-blockers, and three-quarters or more were taking statins and angiotensin-converting enzyme (ACE) inhibitors and were tobacco-free. However, only one-third of patients were physically active. Among the interventions, keeping patients physically active would contribute the largest DPP.[10] The impact of optimizing physical activity was followed by abstaining from tobacco,[11] and increasing use of ACE inhibitors,[12] aspirin,[13] beta-blockers,[14] and statins.[15]

The potential to increase DPP by optimizing care for patients with prevalent CAD and/or HF and an LVEF ≤35% would be 20.1 (plausible range, 6.20 to 35.7). Nearly 80% of these patients were taking aspirin, beta-blockers, and ACE inhibitors; two-thirds or more were taking statins and were tobacco-free. However, only one-third were physically active. Implantable cardioverter-defibrillators (ICDs) or biventricular pacemakers were implanted in only about 40%, and only 20% were taking spironolactone. As with patients with an LVEF >35%, the largest increase in DPP would be achieved by keeping patients physically active.[16] Optimizing the use of ICDs or biventricular pacemakers would contribute a DPP of 6.50.[17] The impact of increasing spironolactone use would be nearly the same,[18] with abstaining from tobacco[11] and increasing the use of beta-blockers,[19] ACE inhibitors,[20] aspirin,[13] and statins[15] having less impact.

… the largest opportunity to increase the deaths prevented or postponed would accrue from optimizing care for ambulatory patients.

Acute events: For patients hospitalized with STEMI, the DPP achieved by optimizing care would be 0.70 (Table 5). Nearly 100% of patients presenting with STEMI were given aspirin, beta-blockers, statins, rescue angioplasty, and a prescription to participate in cardiac rehabilitation. Two-thirds of patients had quit smoking at the time of the STEMI, and 80% were given ACE inhibitors. The largest increase in DPP would accrue from increasing abstinence from tobacco,[11] followed by increasing ACE inhibitor use.[21] Because all patients receive rescue angioplasty, rescue thrombolysis would have no effect.[22]

Optimizing care for acute HF with an LVEF ≤35% has the potential to yield a combined DPP of 9.6 (plausible range, 2.5 to 21.6). Nearly 100% of these patients were given ACE inhibitors and beta-blockers; more than 85% were given aspirin, nearly 75% were given statins and were abstaining from tobacco at the time of hospitalization. However, only 30% were given spironolactone, and less than 20% participated in cardiac rehabilitation. The largest increase in DPP would come from increasing enrollment in cardiac rehabilitation[23] followed by a prescription of spironolactone,[18] abstaining from tobacco,[11] and using statins[24] and aspirin.[13] Because beta-blockers and ACE inhibitors are already used in nearly 100% of patients, increasing the use of these medications would increase the DPP to a very limited extent.[19,20]

The combined potential to increase the DPP for patients hospitalized with an nSTEMI could be as large as 1.4 (plausible range, 0.1 to 4.5). Nearly 100% of these patients were given aspirin, beta-blockers, and statins; three-fourths were given clopidogrel and ACE inhibitors. However, only 50% were acutely revascularized, nearly 25% were still smoking, only two-thirds of patients participated in cardiac rehabilitation, and 40% were not given a glycoprotein IIb/IIIa inhibitor. The largest potential increase in DPP would accrue from increased immediate revascularization,[25] followed by increasing abstinence from tobacco,[11] increasing participation in cardiac rehabilitation,[26] and prescribing IIb/IIIa inhibitors,[27] clopidogrel,[28] and ACE inhibitors.[21]

The combined potential to increase DPP for patients hospitalized with UA could be as large as 2.8 (plausible range, 0.1 to 11.3). Nearly 100% of these patients were given aspirin and beta-blockers, and roughly 80% were given statins and ACE inhibitors. However, only 60% participated in cardiac rehabilitation, and nearly 10% continued to smoke. The largest increase in DPP would come from increasing participation in cardiac rehabilitation,[26] followed by increasing abstinence from tobacco,[11] and increasing the use of statins,[15] ACE inhibitors,[21] and aspirin.[13]

The combined potential increase in DPP for patients in CAD and/or HF newly diagnosed in the ambulatory setting was 9.7 (plausible range, 1.9 to 24.8). More than 90% of these patients were given a prescription for aspirin, and three-fourths were given beta-blockers and statins. However, only about 15% of the patients participated in cardiac rehabilitation, one-fourth continued to smoke, and one-third were not given a prescription for ACE inhibitors. The largest increase in DPP would come from increasing participation in cardiac rehabilitation[26] followed by increasing abstinence from tobacco[11] and increasing the use of beta-blockers,[14] ACE inhibitors,[29] statins,[15] and aspirin.[13]

Table 4. The potential impact of optimizing care for patients with stable coronary artery disease and/or heart failure

Intervention goal	Expected mortality reduction in the candidate population (plausible range)[a]	Current level of implementation (plausible range)[a]	Additional DPPs by optimizing care (plausible range)[a]
Symptomatic heart disease with an LVEF >35%			
Aspirin	0.20[1] (0.16 – 0.24)	0.85 (0.68 – 1.00)	2.30 (0.00 – 8.60)
Beta blocker	0.23[2] (0.15 – 0.31)	0.88 (0.70 – 1.00)	2.20 (0.00 – 10.3)
Statin	0.12[3] (0.09 – 0.16)	0.79 (0.63 – 0.95)	2.00 (0.20 – 6.60)
Abstain from tobacco	0.36[4] (0.29 – 0.42)	0.84 (0.67 – 1.00)	4.50 (0.00 – 15.5)
Eliminate ETS	0.01[5] (0.01 – 0.01)	0.35 (0.28 – 0.42)	0.60 (0.20 – 1.20)
ACE inhibitors	0.16[6] (0.05 – 0.25)	0.73 (0.58 – 0.88)	3.40 (0.30 – 11.7)
Remain physically active	0.42[7] (0.25 – 0.71)	0.33 (0.26 – 0.40)	22.00 (7.50 – 58.8)
Combined potential			31.90 (8.10 – 82.3)
Symptomatic heart disease with an LVEF ≤35%			
Aspirin	0.20[1] (0.16 – 0.24)	0.77 (0.62 – 0.92)	1.20 (0.20 – 3.50)
Beta blocker	0.37[8] (0.28 – 0.45)	0.77 (0.62 – 0.92)	2.30 (0.40 – 6.60)
ACE inhibitors	0.24[9] (0.17 – 0.34)	0.80 (0.64 – 0.96)	1.30 (0.10 – 4.60)
Abstain from tobacco	0.36[4] (0.29 – 0.42)	0.70 (0.56 – 0.84)	2.80 (0.80 – 7.00)
Eliminate ETS	0.00[5] (0.00 – 0.00)	0.35 (0.28 – 0.42)	0.00 (0.00 – 0.10)
Statin	0.12[3] (0.09 – 0.16)	0.70 (0.56 – 0.84)	1.00 (0.20 – 2.70)
Spironolactone	0.30[10] (0.18 – 0.40)	0.20 (0.16 – 0.24)	6.30 (2.30 – 12.8)
Remain physically active	0.63[11] (0.16 – 0.83)	0.33 (0.26 – 0.40)	11.10 (1.60 – 23.2)
ICD or biventricular pacemaker	0.43[12] (0.20 – 0.60)	0.43 (0.34 – 0.52)	6.50 (1.60 – 14.9)
Combine potential			20.10 (6.20 – 35.7)

[a] The plausible range is defined as ±20% of the observed value.
ACE = angiotensin-converting enzyme; DPP = deaths prevented or postponed; ETS = environmental tobacco smoke; LVEF = left ventricular ejection fraction; ICD = implantable cardioverter-defibrillator

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Table 5. The potential impact of optimizing care with an acute coronary artery disease and/or heart failure event

Intervention goal	Expected mortality reduction in the candidate population (plausible range)[a]	Current level of implementation (plausible range)[a]	Additional DPPs by optimizing care (plausible range)[a]
With STEMI			
Aspirin	0.20[1] (0.16 – 0.24)	1.00 (0.80 – 1.00)	0.00 (0.00 – 0.30)
Beta blocker	0.04[2] (-0.08 – 0.15)	1.00 (0.80 – 1.00)	0.00 (0.00 – 0.20)
ACE inhibitors	0.07[3] (0.02 – 0.11)	0.80 (0.64 – 0.96)	0.10 (0.00 – 0.30)
Statins	0.12[4] (0.09 -0.16)	0.97 (0.78 – 1.00)	0.00 (0.00 – 0.30)
Angioplasty[b]	0.33[5] (0.26 – 0.40)	0.66 (0.53 – 0.79)	0.60 (0.20 – 1.40)
Abstain from tobacco	0.36[6] (0.29 – 0.42)	0.66 (0.53 – 0.79)	0.60 (0.20 – 1.40)
Eliminate ETS	0.00[7] (0.00 – 0.00)	0.35 (0.28 – 0.42)	0.00 (0.00 – 0.00)
Cardiac rehabilitation	0.20[8] (0.07 – 0.32)	0.97 (0.78 – 1.00)	0.00 (0.00 – 0.50)
Combined potential			0.70 (0.20 – 3.20)
Acute heart failure with LVEF ≤35%			
Aspirin	0.26[1] (0.23 – 0.29)	0.86 (0.69 – 1.00)	0.60 (0.00 -2.40)
Beta blocker	0.37[9] (0.28 – 0.45)	0.97 (0.78 – 1.00)	0.20 (0.00 – 2.70)
Spironolactone	0.30[10] (0.28 – 0.40)	0.30 (0.24 – 0.36)	3.70 (1.30 – 8.10)
ACE inhibitors	0.26[11] (0.17 – 0.34)	1.00 (0.80 – 1.00)	0.00 (0.00 – 1.80)
Statins	0.20[12] (0.16 – 0.24)	0.73 (0.58 – 0.88)	1.00 (0.20 – 2.70)
Abstain from tobacco	0.36[6] (0.29 – 0.42)	0.73 (0.58 – 0.88)	1.70 (0.40 – 4.70)
Eliminate ETS	0.00[7] (0.00 – 0.00)	0.35 (0.28 – 0.42)	0.00 (0.00 – 0.10)
Cardiac rehabilitation	0.35[13] (0.08 – 0.54)	0.19 (0.15 – 0.23)	5.00 (0.70 – 12.2)
Combined potential			9.60 (2.50 – 21.6)
With nSTEMI			
Aspirin	0.20[1] (0.16 – 0.24)	0.97 (0.78 – 1.00)	0.00 (0.00 – 0.40)
Beta blocker	0.04[2] (-0.08 – 0.15)	1.00 (0.80 – 1.00)	0.00 (0.00 – 0.20)
Clopidogrel	0.07[14] (-0.08 – 0.21)	0.74 (0.59 – 0.89)	0.10 (0.00 – 0.60)
ACE inhibitors	0.07[3] (0.02 – 0.11)	0.80 (0.64 – 0.96)	0.10 (0.00 – 0.30)
IIb/IIIa inhibitors	-0.10[15] (-0.29 – 0.14)	0.60 (0.48 – 0.72)	0.20 (0.20 – 0.50)
Immediate revascularization	0.37[16] (0.23 – 0.48)	0.54 (0.43 – 0.65)	0.80 (0.20 – 1.90)
Statins	0.12[4] (0.09 – 0.16)	1.00 (0.80 – 1.00)	0.00 (0.00 – 0.20)
Abstain from tobacco	0.36[6] (0.29 – 0.42)	0.74 (0.59 – 0.89)	0.40 (0.10 – 1.20)
Eliminate ETS	0.00[7] (0.00 – 0.00)	0.35 (0.28 – 0.42)	0.00 (0.00 0.00)
Cardiac rehabilitation	0.20[8] (0.07 – 0.32)	0.66 (0.53 – 0.79)	0.30 (0.00 – 1.10)
Combined potential			1.40 (0.10 – 4.50)
With unstable angina[c]			
Aspirin	0.20[1] (0.16 – 0.24)	0.96 (0.77 – 1.00)	0.10 (0.00 – 1.40)
Beta blocker	0.04[2] (-0.08 – 0.15)	0.96 (0.77 – 1.00)	0.00 (0.00 – 1.90)
Clopidogrel	0.07[14,17] (-0.08 – 0.21)	0.54 (0.43 – 0.65)	0.00 (-0.03 – 3.00)
ACE inhibitors	0.07[3] (0.02 – 0.11)	0.82 (0.66 – 0.98)	0.20 (0.00 – 0.90)
Statins	0.12[4] (0.09 – 0.16)	0.79 (0.63 – 0.95)	0.40 (0.00 – 1.50)
Abstain from tobacco	0.36[6] (0.29 – 0.42)	0.93 (0.74 – 1.00)	0.40 (0.00 – 2.70)
Eliminate ETS	0.00[7] (0.00 – 0.00)	0.35 (0.28 – 0.42)	0.00 (0.00 – 0.01)
Cardiac rehabilitation	0.20[10] (0.07 – 0.32)	0.64 (0.51 – 0.77)	1.20 (0.20 – 3.90)
Combined potential			2.80 (0.10 – 11.3)

Continued on next page.

Table 5 continued.

Intervention goal	Expected mortality reduction in the candidate population (plausible range)[a]	Current level of implementation (plausible range)[a]	Additional DPPs by optimizing care (plausible range)[a]
For ambulatory or incidental presentation			
Aspirin	0.25[1] (0.23 – 0.27)	0.94 (0.75 – 1.00)	0.40 (0.00 – 2.80
Beta blocker	0.23[2] (0.15 – 0.31)	0.75 (0.60 – 0.90)	1.60 (0.30 – 5.30)
ACE inhibitors	0.13[18] (0.06 – 0.19)	0.66 (0.53 – 0.79)	1.30 (0.20 – 3.80)
Statins	0.12[4] (0.09 – 0.16)	0.78 (0.62 – 0.94)	0.70 (0.10 – 2.60)
Abstain from tobacco	0.36[6] (0.29 – 0.42)	0.78 (0.62 – 0.94)	2.20 (0.30 – 6.70)
Eliminate ETS	0.01[7] (0.01 – 0.01)	0.35 (0.28 – 0.42)	0.20 (0.10 – 0.40)
Cardiac rehabilitation	0.20[8] (0.07 – 0.32)	0.16 (0.13 – 0.19)	4.80 (1.00 – 11.9)
Combined potential			9.70 (1.90 – 24.8)

[a] The plausible range is defined as ±20% of the observed value.
[b] All STEMI patients received rescue angioplasty.
[c] Includes all acute heart disease events other than myocardial infarction and heart failure with a left ventricular ejection fraction ≤35%.

ACE = angiotensin-converting enzyme; DPP = deaths prevented or postponed; ETS = environmental tobacco smoke; LVEF = left ventricular ejection fraction; nSTEMI = non-ST-segment elevation myocardial infarction; STEMI = ST-segment elevation myocardial infarction

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The relative magnitude of opportunities to improve outcomes: Among the two ambulatory populations with stable CAD and/or HF and the four types of acute events, the largest opportunity to increase the DPP would accrue from optimizing care for ambulatory patients (Figure 2). Nearly 70% of the total potential increase in DPP by optimizing care would accrue from the two pools of ambulatory patients. With the exception of more aggressive treatment of acute HF with an LVEF ≤35%, very little improvement would be expected from further improvements in care for patients with acute events. Only about 2% of the potential increase in DPP is predicted to accrue from improved care for patients experiencing a STEMI or nSTEMI.

Sensitivity analysis: With the exception of eliminating environmental tobacco smoke exposure, optimizing any single intervention for patients in the two prevalence pools would have a larger impact than optimizing all interventions for STEMI and nSTEMI combined. However, the impact of improving care for patients hospitalized with HF could be as large as improving care for patients with ambulatory presentations.

Comment

In this analysis, we asked two questions: 1) are medical group data adequate to identify opportunities to prevent or postpone death among individuals with heart disease?, and 2) if the data are adequate, are the conclusions generated from medical group data similar to those we previously generated from US statistics? We found that, with the exception of physical activity data, the medical group data were adequate to identify opportunities to prevent or postpone deaths and that the conclusions for a single medical group were consistent with previous conclusions based on national data.[1] We found that nearly 70% of the total opportunity to increase the DPP would accrue from optimizing care of ambulatory patients. Among hospitalized patients, the greatest DPP would accrue from optimizing care for patients with HF with an LVEF ≤35% and patients with UA. Optimizing care for hospitalized patients with either STEMI or nSTEMI would prevent or postpone only about 2% of deaths. This is in part because of the fact that presentation with STEMI or nSTEMI is infrequent relative to other presentations and to the nearly optimal care that patients with STEMI or nSTEMI already receive.

We acknowledge that limitations in the data weaken the conclusions that can be drawn. For example, fatality rates and sheer numbers of patients suggest that many of the patients we classified as having heart disease newly diagnosed in the ambulatory setting

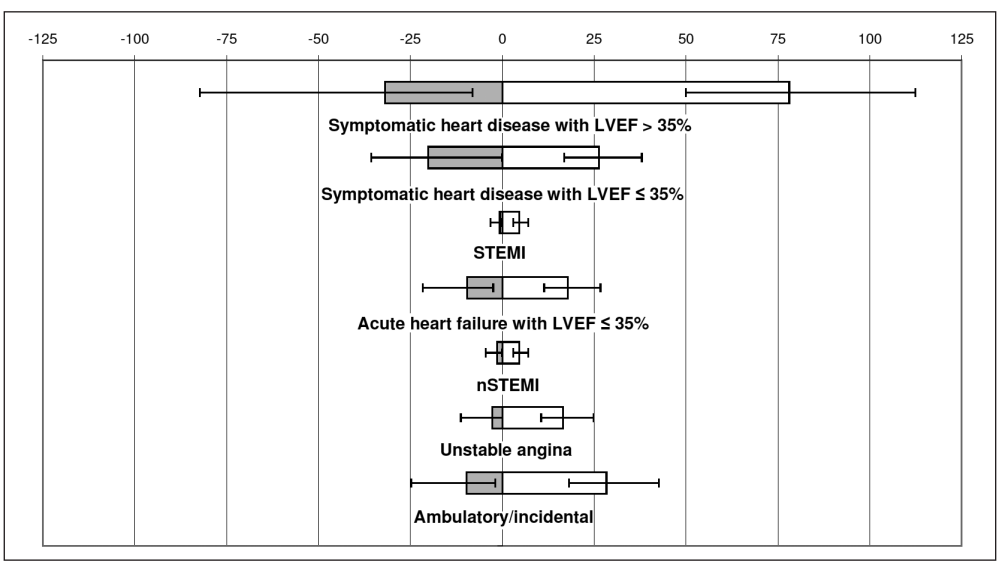

Figure 2. Total deaths and deaths that might be prevented or postponed/100,000 populations ages 40 to 75 years by prevalence pool and type of acute event. Total deaths are represented by the open bars and the deaths that might be prevented or postponed through intervention are represented by the shaded bars. Error bars indicate the range of plausible estimates.

LVEF = left ventricular ejection fraction; nSTEMI = non-ST-segment elevation myocardial infarction; STEMI = ST-segment elevation myocardial infarction

actually had chronic prevalent disease. However, even if this were true, the conclusion would not change: The most significant opportunities to improve outcomes for patients with heart disease lie in the ambulatory setting. Another significant limitation is that we needed to use somewhat different data sets to estimate the number of cases in the population and the opportunities to improve care because we did not have easy access to medical records from other care-delivery systems. This would not be a problem if every medical group analyzed their opportunities to improve outcomes for patients with heart disease as we did. In addition, LVEF was quantified both in the acute setting and outpatient setting, and it is possible that a patient may have had an improvement in their ejection fraction after appropriate medical therapy was given. However, we always selected the highest LVEF and this does not negate the fact that the highest prevalence of patients had higher LVEF's and still accounted for the highest attributable risk for mortality.

Another limitation is the assumption that the effects of multiple interventions are cumulative. We used the method of Mant and Hicks to prevent intervention effects from potentially summing to greater than 100%, but this calculation may not have taken full account for multiple interventions.[4]

Although it is possible to collect nearly all of the data used in this analysis with currently available commercial software, we did need to manually review medical records of patients with acute MI to distinguish between STEMI and nSTEMI; the ICD-9-CM diagnostic codes did not reliably distinguish between STEMI and nSTEMI, a computer-based search of text in the medical record for words indicating STEMI or nSTEMI was unreliable, and the ECG analysis software used by the Medical Group did not permit searching for patients' ECGs for patterns of interest (eg, the words "acute myocardial infarction with ST elevation"). If newer ECG reporting software with the capability to search ECGs for patterns of interest had been available, there would have been no need to manually review any medical record.

A conundrum for quality-improvement efforts that use mortality as an outcome is that death certificate data always lag behind clinical data. We feel that, for the purposes of care-improvement initiatives, it is most important to analyze current clinical practice; because mortality rates are relatively stable for ambulatory cohorts and populations with acute events, using a relatively recent historical cohort to estimate mortality rates should not introduce significant error into the calculations.

Although it would be attractive to have a model that includes all heart disease, which is possible, we chose to limit our codes to CAD and HF for this pilot study. Arrhythmias and valvular heart disease could be included in the analysis as specific conditions, but doing so would add a level of complexity that we wished to avoid. It would also be possible to use the same model to analyze the opportunities to prevent and treat several chronic diseases simultaneously. For example, cerebrovascular disease, peripheral arterial disease, and chronic obstructive pulmonary disorder could be added to the analysis of heart disease opportunities.

This study raises important questions about the current focus of efforts to improve heart disease outcomes in the US. To the extent that the nearly optimal care given to hospitalized patients in this study is representative of the care received by all Americans hospitalized with heart disease, there is relatively little opportunity to improve outcomes by improving care during acute events other than HF with an LVEF ≤35%. The large size of the ambulatory population with CAD and/or HF magnifies the care deficiencies they experience. Although we acknowledge that it is highly unlikely that all patients with heart disease will become physically active, eat a healthy diet, and abstain from tobacco, this analysis shows that even modest improvements in the rates of these behaviors will have the largest impact on outcomes for these patients. ❖

… there is relatively little opportunity to improve outcomes by improving care during acute events other than heart failure with an left ventricular ejection fraction <35%.

Disclosure Statement

The author(s) have no conflicts of interest to disclose.

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