Simultaneous Control of Diabetes Mellitus, Hypertension, and Hyperlipidemia in 2 Health Systems

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Methods and Results—We performed a retrospective cohort study of adults at Denver Health and Kaiser Permanente Colorado with diabetes mellitus, hypertension, and hyperlipidemia from 2000 through 2008. Over a median of 4.0 and 4.4 years, 16% and 30% of individuals at Denver Health and Kaiser Permanente achieved the primary outcome (simultaneous control with a glycosylated hemoglobin (HbA1c) <7.0%, blood pressure <130/80 mm Hg, and low-density lipoprotein cholesterol <100 mg/dL), respectively. With less strict goals (HbA1c <8.0%, blood pressure <140/90 mm Hg, and low-density lipoprotein cholesterol <130 mg/dL), 44% and 70% of individuals at Denver Health and Kaiser Permanente achieved simultaneous control. Sociodemographic characteristics (increasing age, white ethnicity), and the presence of cardiovascular disease or other comorbidities were significantly but not strongly predictive of achieving simultaneous control in multivariable models. Simultaneous control was less likely as severity of the underlying conditions increased, and more likely as medication adherence increased.

Conclusions—Simultaneous control of diabetes mellitus, hypertension, and hyperlipidemia was uncommon and generally transient. Less stringent goals had a relatively large effect on the proportion achieving simultaneous control. Individuals who simultaneously achieve multiple treatment goals may provide insight into self-care strategies for individuals with comorbid health conditions. (Circ Cardiovasc Qual Outcomes. 2012;5:00-00.)

Key Words: diabetes mellitus ■ hypertension ■ hypercholesterolemia ■ epidemiology

In the United States, >75 million people have 2 or more chronic medical conditions. Individuals with multiple health conditions must maintain good nutrition and physical activity, manage complex medication regimens, and monitor themselves for achievement of treatment goals and complications of their conditions. Diabetes mellitus is a prototype for this problem, because people with diabetes mellitus must attain glycemic control and manage common, comorbid cardiovascular disease risk factors such as blood pressure (BP) and hyperlipidemia. Few are successful in simultaneously achieving these goals. In the 2003 to 2006 National Health and Nutrition Examination Survey, only 12% of individuals with diabetes mellitus achieved a glycosylated hemoglobin (HbA1c) <7.0%, systolic BP <130 mm Hg, diastolic BP <80 mm Hg, and a fasting low-density lipoprotein (LDL) cholesterol level <100 mg/dL. Other studies in the United States and Europe confirm a comparably low rate of simultaneous control. Because all these studies were cross-sectional, they assessed only the prevalence of simultaneous control, and not the incidence or maintenance of simultaneous risk factor control, or the severity of the 3 conditions. Furthermore, they did not assess the impact of behaviors such as medication adherence on achievement of these goals. Finally, most of the previous studies did not examine the effect of different threshold values for HbA1c, BP, and LDL cholesterol, which have important implications for the assessment of quality of care.

We analyzed data from 2 healthcare delivery systems in Colorado, an inner-city integrated health care delivery system in Denver (Denver Health [DH]), and a large managed care organization (Kaiser Permanente Colorado [KPCO]), to address 4 questions: (1) Among individuals with concurrent diabetes mellitus, hypertension, and hyperlipidemia, what is the incidence of and proportion maintaining simultaneous control for all 3 conditions? (2) What is the effect of changing goals for HbA1c, BP, and LDL cholesterol on estimates of simultaneous control? (3) Are easily measurable sociodemographic and clinical characteristics, severity of the underlying conditions, or medication adherence associated with simultaneous risk factor control? (4) Do the incidence or predictors of simultaneous control differ between the healthcare systems?
WHAT IS KNOWN

- Individuals with diabetes mellitus must manage multiple cardiovascular risk factors, such as glucose, blood pressure, and cholesterol levels, at the same time.
- Previous studies have found low levels of simultaneous control of these factors, but have been cross-sectional and thus unable to follow risk factor changes over time.

WHAT THE STUDY ADDS

- In these 2 health systems over a median follow-up of over 4 years, simultaneous control of diabetes mellitus, hypertension, and hyperlipidemia was uncommon and generally transient.
- Small changes in the treatment targets had large effects on the proportion of individuals achieving simultaneous control of glucose, blood pressure, and cholesterol levels.

Methods

Study Populations

We conducted this retrospective cohort study using 2 registries: (1) the hypertension registry of DH, a nationally recognized, integrated safety-net delivery system in inner-city Denver, Colorado, and (2) the diabetes mellitus registry of KPCO, a large managed care organization with extensive disease management programs.

Denver Health

DH consists of a 500-bed hospital and 8 neighborhood-based primary care clinics coupled with public health and emergency medical services systems. DH provided care to >140,000 individuals in Denver County in 2007. A clinical information system integrates information from all DH community health centers, emergency services, inpatient services, pharmacies, and the clinical laboratory. Clinical data on BP, smoking status, height, and weight were present in the electronic record for individuals who received care after January 2005. Participants for this study were drawn from a registry of individuals with hypertension who received care at DH between January 1, 2000, and December 31, 2008. The hypertension registry included all DH patients with 1 or more International Classification of Disease, Ninth Revision (ICD-9) codes for hypertension on any outpatient or inpatient claim.

Within this cohort, we identified individuals with diabetes mellitus using ICD-9 codes: 250.xx (diabetes mellitus), 357.xx (polynephropathy in diabetes mellitus), 362.xx (diabetic mellitus retinopathy), and 366.41 (diabetic mellitus cataract). In this population, diabetes mellitus was typically diagnosed at different times, we identified the date of diagnosis of the third of these diseases, and excluded individuals who did not have at least 1 measurement of HbA1c, BP, and LDL cholesterol after that time. The beginning of cohort membership was the date of the diagnosis of the third condition or the date when BPs and laboratory results became available in the electronic record (January 2005 for DH and January 2000 for KP), whichever was later. We defined the end of follow-up as the date of the last clinical measurement of HbA1c, BP, or LDL cholesterol before December 31, 2008.

The study outcome was the occurrence of simultaneous control of HbA1c, systolic and diastolic BP, and LDL cholesterol. We defined risk factor control using the 2002 guidelines from the American Diabetes Association, which were in place for the majority of the study period: HbA1c <7.0%, systolic BP <130 mm Hg, and diastolic BP <80 mm Hg, and fasting LDL cholesterol <100 mg/dL. To estimate the severity of each individual risk factor, we recorded the highest value of each risk factor. We assessed whether individuals achieved control of each risk factor, and if so, whether they subsequently lost and later regained control. BP and laboratory measurements were not necessarily obtained at the same time. Accordingly, we identified time periods during which all risk factor measurements were considered to be guideline-concordant. Any individual who had at least 1 guideline-concordant measurement of each risk factor (HbA1c, BP, and LDL cholesterol) within a 90-day period, without any intervening non–guideline-concordant measurement of any risk factor, was defined as having simultaneous risk factor control. We defined the beginning of an interval of simultaneous control as the time of the first of the 3 guideline-concordant measurements.

Potential sociodemographic and clinical predictors of simultaneous control were derived from registration files, visit claims, laboratory databases, and pharmacy records. There was a substantial amount of missing race information in the KP cohort due to lack of systematic collection of race/ethnicity information during the earlier portions of the study period. Imputation of missing race information using a Bayesian algorithm originally developed by the RAND Corporation based on surnames and geocoded addresses did not substantially change the overall racial distribution. Substance abuse was defined using diagnosis codes; in DH laboratory toxicology screens were also included.

We counted the overall number of comorbid diagnoses using the Quan version of the Elixhauser index, eliminating the 3 conditions of interest (diabetes mellitus, hypertension, and hyperlipidemia), as they were present in all cohort members. We divided the Quan index into a variable for any cardiovascular disease (based on the ICD-9 codes in the Quan index for cardiac arrhythmia, congestive heart failure, valve disease, peripheral vascular disease, and coronary artery disease) and a variable for the other comorbidities in the Quan index.

To assess the intensity of medication treatment, we counted the number of oral hypoglycemics, antihypertensives, and lipid-lowering medications dispensed by the DH or KP pharmacies in the 90 days before the last measurement of any risk factor. We calculated adherence for each medication as the total days’ supply dispensed, divided by the number of days between the first fill and the end of the supply provided in the last fill for that drug, and capped at 1.

Kaiser Permanente Colorado

KPCO is an integrated, group model, not-for-profit Health Maintenance Organization which served 450,000 enrollees in the 6-county Denver/Boulder area in 2008. Electronic data on BP, medication dispensing, laboratory test results, diagnoses, and healthcare utilization was available from electronic health records and administration databases from January 2000. The cohort of participants with diabetes mellitus was based on membership in a validated diabetes mellitus registry. In addition, we required a minimum of 2 years of continuous enrollment and at least 2 diabetes mellitus diagnoses (ICD-9 codes of 250 with a fifth digit of 0 or 2) at any point between January 1998 and September 2008. To identify individuals with hypertension, we used a previously validated algorithm based on ICD-9 codes, dispensed medications, and BP measurements. Previous studies have found high accuracy with these definitions. Hyperlipidemia was defined as an in the DH cohort. We defined the cohort for the current study as all individuals in the diabetes mellitus cohort who also had diagnoses of hypertension and hyperlipidemia.

Study Measures

Because diabetes mellitus, hypertension, and hyperlipidemia were typically diagnosed at different times, we identified the date of diagnosis of the third of these diseases, and excluded individuals who did not have at least 1 measurement of HbA1c, BP, and LDL cholesterol after that time. The beginning of cohort membership was the date of the diagnosis of the third condition or the date when BPs and laboratory results became available in the electronic record (January 2005 for DH and January 2000 for KP), whichever was later. We defined the end of follow-up as the date of the last clinical measurement of HbA1c, BP, or LDL cholesterol before December 31, 2008.
Statistical Analysis

All analyses were stratified by health care delivery system. We conducted bivariate analyses to identify associations between all candidate predictors and the achievement of simultaneous risk factor control, using t-tests or Wilcoxon rank-sum tests for continuous variables, and χ² or Fisher exact tests for dichotomous or categorical predictors. Using logistic regression to estimate the odds of ever achieving simultaneous risk factor control, we first examined sociodemographic variables and clinical diagnosis with a P value of <0.25. Backward elimination was performed, checking at each step to assure that odds ratios did not change significantly, until all remaining variables in the model had a P value of <0.05 in at least 1 of the study cohorts. We then added the number of medications for all 3 conditions, medication adherence, and the highest value of each target conditions, as a proxy for severity of the underlying conditions. All models were adjusted for length of follow-up. We assessed model discrimination with the c-statistic.

This study was approved by the Colorado Multiple Institutional Review Board and the institutional review board of KPCO. Analyses were conducted with SAS Versions 9.1 and 9.2 (SAS Institute, Inc., Cary, NC).

Results

The characteristics of the study populations are shown in Table 1. There were 5269 individuals in the DH cohort and 23,458 individuals in the KP cohort, with a median follow-up time...
of 4.0 and 4.4 years, respectively. Compared with the KP cohort, the DH cohort was younger (mean age of 56.4 versus 62.0 years), and had a smaller proportion of men (39.0 versus 52.2%) and a higher proportion of racial minorities (81.5 versus 31.4% of individuals without missing race information). In the DH cohort, 28.7% reported Spanish as their primary language, whereas in the KP cohort only 2% requested interpreters.

The percentages ever meeting the goals for the individual risk factors ranged from 61.0 to 89.1%, with slightly higher percentages in the KP cohort (Table 2). Fluctuations in control of each risk factor were common. Only 16.2% of the DH cohort and 30.3% of the KP cohort ever achieved simultaneous control of all 3 risk factors (Figure 1, Table 2). Once achieving simultaneous control, few individuals were able to maintain it. Among those with at least 90 days of follow-up after achieving simultaneous control, 23% of the DH cohort and 39% of the KP cohort subsequently lost and then regained control, whereas 64% of the DH cohort and 56% of the KP cohort lost control and never regained it, and only 13% of the DH cohort and 5% of the KP cohort never lost control. In both cohorts, loss of simultaneous control was most commonly due to elevated BP (82% for KP intervals, 92% for DH), followed by HbA1c (12% for KP, 20% for DH), and LDL cholesterol (7% for KP, 8% for DH; percentages do not sum to 100% because loss of simultaneous control could be due to >1 risk factor). Increasing the allowed period for achieving simultaneous control from 90 to 365 days only slightly increased the proportion ever achieving simultaneous control (34.1% for KP, 18.1% for DH). With the 90-day definition, almost all individuals had at least 1 opportunity to achieve simultaneous control (98.2% for KP; 92.3% for DH).

Using less stringent risk factor cut points, over twice as many people simultaneously achieved a HbA1c <8%, BP <140/90 mm Hg, and LDL cholesterol <130 mg/dL than achieved the stricter American Diabetes Association guidelines (Figure 2).

Table 2. Individual Risk Factor Control in Individuals With Diabetes Mellitus, Hypertension, and Hyperlipidemia

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Median Duration in Days (IQR) of Initial Interval of Control</th>
<th>Median Percentage of Subsequent Time Period Controlled* (%)</th>
<th>Median Days of Follow up After Achieving Control</th>
<th>n (%), Ever Losing Control</th>
<th>n (%), Regaining Control After Losing Control†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denver Health</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HbA1c</td>
<td>78 (1-441)</td>
<td>20.6</td>
<td>2897 (90.1)</td>
<td>2299 (79.4)</td>
<td>977 (42.5)</td>
</tr>
<tr>
<td>Blood pressure</td>
<td>34 (1-108)</td>
<td>12.1</td>
<td>3904 (95.0)</td>
<td>3697 (94.7)</td>
<td>2539 (68.7)</td>
</tr>
<tr>
<td>LDL cholesterol</td>
<td>178 (1-796)</td>
<td>53.2</td>
<td>3790 (85.8)</td>
<td>2702 (71.3)</td>
<td>1235 (45.7)</td>
</tr>
<tr>
<td>Simultaneous control</td>
<td>48 (3-132)</td>
<td>17.0</td>
<td>691 (80.7)</td>
<td>601 (87.0)</td>
<td>158 (26.3)</td>
</tr>
<tr>
<td>Kaiser Permanente Colorado</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HbA1c</td>
<td>201 (1-696)</td>
<td>40.4</td>
<td>14731 (91.6)</td>
<td>10185 (69.1)</td>
<td>5699 (56.0)</td>
</tr>
<tr>
<td>Blood pressure</td>
<td>1 (1-57)</td>
<td>12.7</td>
<td>19729 (94.4)</td>
<td>19023 (96.4)</td>
<td>16696 (87.8)</td>
</tr>
<tr>
<td>LDL cholesterol</td>
<td>311 (1-932)</td>
<td>78.8</td>
<td>17932 (89.9)</td>
<td>9978 (55.6)</td>
<td>7747 (77.6)</td>
</tr>
<tr>
<td>Simultaneous control</td>
<td>76 (24-183)</td>
<td>15.9</td>
<td>6658 (93.6)</td>
<td>6320 (94.9)</td>
<td>2599 (41.1)</td>
</tr>
</tbody>
</table>

IQR indicates interquartile range; LDL, low-density lipoprotein. *Among individuals with ≥90 days follow-up after achieving control. †Among individuals ever losing control of that condition.

Cohorts

- Denver Health (DH): n=5269
- Kaiser Permanente Colorado (KP): n=23458

Did not ever achieve control

- DH: n=4413 (84%)
- KP: n=16341 (70%)

Ever achieved control

- DH: n=856 (16%)
- KP: n=7117 (30%)

<90 days of follow-up following first interval of control

- DH: n=4413 (84%)
- KP: n=16341 (70%)

≥90 days of follow-up following first interval of control

- DH: n=856 (16%)
- KP: n=7117 (30%)

Never lost control

- DH: n=90 (13%)
- KP: n=338 (5%)

Lost but regained control

- DH: n=158 (23%)
- KP: n=2599 (39%)

Lost and never regained control

- DH: n=443 (64%)
- KP: n=3721 (56%)

Figure 1. Achievement and maintenance of simultaneous control of glycosylated hemoglobin (HbA1c), blood pressure, and low-density lipoprotein (LDL) cholesterol in 2 Colorado cohorts of individuals with diabetes mellitus, hypertension, and hyperlipidemia.

Figure 2. Effect of varying goals for glycosylated hemoglobin (HbA1c) blood pressure (BP), and low-density lipoprotein (LDL) cholesterol (LDL-C) on the percent ever achieving simultaneous control.
Bivariate comparisons between individuals ever achieving simultaneous risk factor control and those who did not were largely similar between the 2 cohorts (Table 1). Individuals who achieved simultaneous control had longer follow-up time, were older, and were more likely to be white, have diagnosed cardiovascular disease, and had more comorbid conditions. Individuals in the DH cohort who achieved simultaneous control were also more likely to be Hispanic, whereas individuals in the KP cohort who achieved simultaneous control were more likely to be men, less likely to be current smokers, and were slightly leaner. In the DH cohort, primary language was not associated with achievement of simultaneous control. Individuals who achieved simultaneous control had lower maximum values for HbA1c, BP, and LDL cholesterol.

Medication information was unavailable in 25.3% of the DH cohort and 6.9% of the KP cohort. These individuals represent a mix of individuals who obtained their medications at pharmacies external to the health systems and individuals who were not taking any medications for diabetes mellitus, hypertension, or hyperlipidemia. After excluding individuals with missing medication information, those who received fewer medications for diabetes mellitus or hypertension or were not receiving insulin were more likely to achieve simultaneous control, whereas those receiving any medication for hyperlipidemia were more likely to attain simultaneous control (Table 3). Medication adherence was higher in the KP cohort than in the DH cohort, and in individuals who achieved simultaneous control than in those who did not.

Clinical utilization and risk factor measurement rates are shown in Table 4. Some of the rate distributions are skewed, and thus the median is the better measure of their central tendencies. For both populations, primary care visits were somewhat more frequent among those who achieved simultaneous control. The frequency of measurement of individual risk factors was slightly more frequent among those who achieved simultaneous control than those who did not.

In a multivariable model that included only sociodemographic risk factors and clinical diagnoses, age, race/ethnicity, and the presence of cardiovascular and noncardiovascular comorbidities were associated with simultaneous control (Table 5, Model 1). In addition, men were more likely to achieve simultaneous control. Despite the statistical significance of these predictors, the model discrimination was only fair. Limiting Model 1 to individuals with available medication information did not substantially change the odds ratios or c-statistics (data not shown). Inclusion of maximum risk factor values and medication information increased the c-statistics (Table 5, Model 2).

**Discussion**

In this study of patients receiving care in 2 integrated delivery systems, we found that 16% and 30% of individuals with diabetes mellitus, hypertension, and hyperlipidemia achieved simultaneous control of all 3 conditions, as defined by 2002 American Diabetes Association guidelines, over a median of 4.0 and 4.4 years of follow-up. Among those with at least 90 days of follow-up after achieving simultaneous control, only 13 and 5% of the DH and KP cohorts, respectively, maintained simultaneous control until the end of the observation period. The predictors of ever achieving simultaneous control were similar in the 2 populations. Sociodemographic and clinical

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**Table 3. Pharmacological Treatment and Adherence of Individuals With Diabetes Mellitus, Hypertension, and Hyperlipidemia by Achievement of Simultaneous Control of HbA1c, Blood Pressure, and LDL Cholesterol**

<table>
<thead>
<tr>
<th></th>
<th>Denver Health (n=5269)</th>
<th>Kaiser Permanente Colorado (n=23,458)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Simultaneous Control (n=4413)</td>
<td>Simultaneous Control (n=856)</td>
</tr>
<tr>
<td>Medication adherence*, mean (SD)/median</td>
<td>61.2 (23.3)/62.6</td>
<td>72.3 (18.7)/74.9</td>
</tr>
<tr>
<td>Any medication dispensed in the last 90 days of follow-up* (n%)</td>
<td>3301 (74.8%)</td>
<td>635 (74.2%)</td>
</tr>
<tr>
<td>No of hypertensive medications, %†</td>
<td>0</td>
<td>8.5</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>30.9</td>
</tr>
<tr>
<td></td>
<td>2–3</td>
<td>45.8</td>
</tr>
<tr>
<td></td>
<td>4 or more</td>
<td>14.8</td>
</tr>
<tr>
<td>No of oral hypoglycemic medications, %†</td>
<td>0</td>
<td>28.1</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>32.4</td>
</tr>
<tr>
<td></td>
<td>2 or more</td>
<td>39.5</td>
</tr>
<tr>
<td>Any cholesterol-lowering medication, %†</td>
<td>69.0</td>
<td>80.2</td>
</tr>
<tr>
<td>Any insulin, %†</td>
<td>34.0</td>
<td>15.6</td>
</tr>
</tbody>
</table>

LDL indicates low-density lipoprotein.

*Any medication for diabetes mellitus, hypertension, or hyperlipidemia.

†Assessed in the 90 days before last clinical measurement of any of the 3 conditions, among individuals with at least one medication for diabetes mellitus, hypertension, or hyperlipidemia dispensed in the last 90 days of observation.
Characteristics did not discriminate accurately between individuals who attained simultaneous control and those who did not, whereas maximum risk factor values, medication patterns, and medication adherence improved model discrimination.

Previous studies of simultaneous risk factor control among individuals with diabetes mellitus have reported prevalence rates, whereas we determined incidence rates. Incidence data has the advantage of giving a fuller picture of what a cohort of individuals is able to achieve over time, as well as allowing examination of maintenance of control. Previously reported prevalence rates from several countries have been low, mostly in the 5 to 20% range. For example, a study using National Health and Nutrition Examination Survey data found the prevalence of simultaneous achievement of a HbA1c <7.0%, BP <130/80 mm Hg, and LDL cholesterol <100 mg/dL was 7.0% in 1999 to 2002 and 12.2% in 2003 to 2006. A study from the Veterans Affairs National Diabetes Registry in 1999 to 2000, using the same criteria, found a 3.9% rate of simultaneous control.

Most previous studies have only examined 1 set of criteria for achievement of simultaneous control. The study from the Veterans Affairs National Diabetes Registry also examined less stringent criteria (HbA1c <9%, BP <140/90 mm Hg, and LDL cholesterol <130 mg/dL) and found a prevalence of 30.7%. In the last several years, the optimal level of risk factor control to prevent macrovascular outcomes has been a matter of increasing debate. In addition, there has been an ongoing discussion about whether item-by-item measurements, composite measurements, or all-or-none measurements are the most effective for judging quality of care and motivating improvement in quality. All-or-none measurements, such as our assessment of simultaneous risk factor control in diabetes mellitus, takes the patient’s perspective, as the patient is the unit of analysis. It is also a more sensitive measure of quality improvement than item-by-item measurements. Our study illustrates that when continuous measurements (such as HbA1c, BP, and LDL cholesterol) are transformed into dichotomous threshold-based measures, relatively small differences in cut points can have large effects on conclusions concerning quality of care. Selection of an appropriate threshold can be difficult, especially with the greater emphasis on individualized clinical goals in diabetes mellitus. Using high threshold goals means that the goals are appropriate for almost all individuals and focuses attention on individuals who are the furthest from the optimal levels and who therefore have the most to gain. However, it does not encourage the healthcare system to help most individuals achieve optimal levels. In contrast, using stricter threshold goals means the risks of the resulting aggressive treatment will exceed the potential benefits for some individuals.

The frequency of risk factor measurement has implications for our assessment of simultaneous control. Individuals could only be in simultaneous control if they had all 3 risk factors measured within 90 days. The differences in the risk factor measurement rates between those who did and did not achieve simultaneous control were relatively small. Increasing the allowed period for achieving simultaneous control did not substantially change our findings. The frequency of risk factor measurement also has implications for the maintenance of simultaneous control, as individuals could only fall out of simultaneous control when they had risk factors measured.

Table 4. Utilization Rates and Frequency of Risk Factor Measurement of Individuals With Diabetes Mellitus, Hypertension, and Hyperlipidemia by Achievement of Simultaneous Control Of HbA1c Blood Pressure, and LDL Cholesterol

<table>
<thead>
<tr>
<th></th>
<th>Denver Health (n=5 269)</th>
<th>Kaiser Permanente Colorado (n=23 458)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Simultaneous Control (n=4413)</td>
<td>Simultaneous Control (n=856)</td>
</tr>
<tr>
<td>Annual utilization rates, mean (SD)/median*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary care visits</td>
<td>4.8 (5.2)/4.0</td>
<td>4.9 (3.1)/4.4</td>
</tr>
<tr>
<td>Specialty (cardiology, endocrinology, and renal)</td>
<td>0.4 (1.1)/0.0</td>
<td>0.5 (1.1)/0.0</td>
</tr>
<tr>
<td>ED visits</td>
<td>1.0 (3.7)/0.4</td>
<td>0.9 (2.4)/0.4</td>
</tr>
<tr>
<td>Inpatient visits</td>
<td>0.4 (1.8)/0.0</td>
<td>0.5 (2.0)/0.0</td>
</tr>
<tr>
<td>Annual measurement rates, mean (SD)/median*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HbA1c</td>
<td>2.1 (3.1)/1.9</td>
<td>2.1 (0.9)/2.0</td>
</tr>
<tr>
<td>Blood pressure</td>
<td>3.4 (4.5)/2.5</td>
<td>3.5 (2.6)/2.9</td>
</tr>
<tr>
<td>LDL cholesterol</td>
<td>1.4 (3.1)/1.1</td>
<td>1.3 (0.6)/1.2</td>
</tr>
</tbody>
</table>

ED indicates emergency department; LDL, low-density lipoprotein; and HbA1c, glycosylated hemoglobin.

*Assessed from date when all 3 conditions were first present until date of last clinical measurement of any of the 3 conditions.
The higher rate of simultaneous control in KP compared with DH is likely the result of both patient level and system level factors. Compared with the KP population, the DH population has a much higher proportion of individuals with low socioeconomic position; the reasons for poorer health in socioeconomically disadvantaged individuals are complex but likely result from more than just limited access to health care. Second, based on our multivariable models, the KP cohort would be predicted to have a higher rate of simultaneous control on the basis of its age, sex, disease severity, and comorbidity profile. Third, the higher medication adherence of the KP cohort than the DH cohort likely explains some of the differences. Fourth, differences in physician practices between the 2 systems, such as different degrees of treatment intensification or different goal setting, could potentially explain some of the differences. Finally, KP has been able to devote substantially more resources to population-based management systems over a period of many years. Population-based mechanisms for identifying individuals who have not achieved simultaneous control and treating elevated risk factors could potentially help improve achievement and maintenance of simultaneous control. Focusing on BP, in particular, would be most likely to increase achievement of simultaneous control.

Our findings contribute to the literature in several ways. First, we assessed achievement of simultaneous control in 2 disparate health care systems within the same region. Second, our longitudinal study could assess incidence rather than prevalence of simultaneous risk factor control. Third, we were able to conduct a detailed analysis of the predictors of simultaneous risk factor control. Fourth, we were able to conduct a detailed analysis of the predictors of simultaneous risk factor control. Fifth, we were able to conduct a detailed analysis of the predictors of simultaneous risk factor control. Sixth, we were able to conduct a detailed analysis of the predictors of simultaneous risk factor control.

Table 5. Predictors of Achieving Simultaneous Risk Factor Control Among Individuals with Diabetes Mellitus, Hypertension, and Hyperlipidemia

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Denver Health</th>
<th>Kaiser Permanente Colorado</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model (odds ratios with 95% CI)*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (per 10 y)</td>
<td>1.12 (1.04–1.20)</td>
<td>1.10 (1.00–1.22)</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>0.60 (0.46–0.77)</td>
<td>0.91 (0.64–1.30)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>1.02 (0.84–1.23)</td>
<td>1.57 (1.20–2.05)</td>
</tr>
<tr>
<td>White</td>
<td>1.03 (0.62–1.72)</td>
<td>1.27 (0.63–2.54)</td>
</tr>
<tr>
<td>Other</td>
<td>0.94 (0.49–1.80)</td>
<td>1.02 (0.42–2.47)</td>
</tr>
<tr>
<td>Male</td>
<td>1.10 (0.94–1.28)</td>
<td>1.06 (0.87–1.30)</td>
</tr>
<tr>
<td>Any cardiovascular comorbidities†</td>
<td>1.14 (1.05–1.24)</td>
<td>1.08 (0.97–1.20)</td>
</tr>
<tr>
<td>Other comorbidities†</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.25 (1.02–1.53)</td>
<td>1.09 (0.85–1.40)</td>
</tr>
<tr>
<td>2</td>
<td>1.24 (0.99–1.57)</td>
<td>1.07 (0.80–1.44)</td>
</tr>
<tr>
<td>3 or more</td>
<td>1.76 (1.41–2.21)</td>
<td>1.79 (1.34–2.38)</td>
</tr>
<tr>
<td>Highest HbA1c (per 1% increase)</td>
<td>0.99 (0.86–0.93)</td>
<td>0.79 (0.78–0.81)</td>
</tr>
<tr>
<td>Highest systolic BP (per 10 mm Hg increase)</td>
<td>0.78 (0.74–0.82)</td>
<td>0.85 (0.83–0.86)</td>
</tr>
<tr>
<td>Highest LDL cholesterol (per 10 mg/dL increase)</td>
<td>0.96 (0.93–0.98)</td>
<td>0.93 (0.92–0.94)</td>
</tr>
<tr>
<td>Insulin‡</td>
<td>0.38 (0.29–0.50)</td>
<td>0.54 (0.49–0.59)</td>
</tr>
<tr>
<td>Oral hypoglycemic medication‡</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.20 (0.94–1.54)</td>
<td>0.95 (0.88–1.02)</td>
</tr>
<tr>
<td>2 or more</td>
<td>0.60 (0.45–0.79)</td>
<td>0.57 (0.52–0.63)</td>
</tr>
<tr>
<td>Blood pressure medication‡</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.75 (1.38–2.22)</td>
<td>1.80 (1.66–1.96)</td>
</tr>
<tr>
<td>2 or more</td>
<td>0.60 (0.45–0.79)</td>
<td>0.57 (0.52–0.63)</td>
</tr>
<tr>
<td>Medication adherence for BP, oral hypoglycemic and cholesterol medication (per 10 percentage points)</td>
<td>1.26 (1.20–1.32)</td>
<td>1.14 (1.11–1.17)</td>
</tr>
</tbody>
</table>

BP indicates blood pressure; CI, confidence interval; Ref., referent, and LDL, low-density lipoprotein.

*Model 1: Demographics and clinical diagnoses only; Model 2: Demographics, clinical diagnoses, medication adherence, number of medications, and severity of target conditions. All models adjusted for duration of observation and smoking status.
†As measured using the Quan index.‡Dispensed in the 90 days before the last clinical measurement of any of the 3 conditions.
simply prevalence of simultaneous control. As a result, we
determined that sustained simultaneous risk factor control was
rare and brief, especially using stringent guidelines. Third, no
previous study has assessed either the severity of the individual
diseases, medication adherence, or health care utilization as
correlates of simultaneous control. Finally, although previous
studies had identified sociodemographic and clinical variables
associated with simultaneous control, they did not report the
discrimination of their statistical models. The low c-statistics of
Model 1 suggests that clinicians and researchers need to look
beyond these conventional and easily obtainable measures if
they are to identify useful predictors of self-management for
diabetes mellitus.10

This study has several limitations. First, because we took
advantage of existing cohorts, the inclusion and exclusion crit-
eria differed slightly for the 2 different health care systems.
Second, because all data were obtained in routine clinical
practice, the number of measurements of clinical and timing
of outcomes was variable, and there was missing data on
some variables (most notably medication use in DH and race
information in KP). Third, we were not able to determine the
pretreatment severity of diabetes mellitus, hypertension, or
hyperlipidemia, and had to use the highest available measure-
ment, which could be confounded by a number of factors, as
a proxy. Fourth, individuals could receive services from other
health care providers and systems, although this was likely
limited. For all these reasons, our findings may not be gener-
alizable to other populations or settings.

Individuals who are able to achieve simultaneous treatment
goals can be viewed as positive deviants,11,12 whose strategies
for self-care may provide important lessons for other individu-
als. The degree of statistical discrimination provided by a mul-
tivariable model based only on sociodemographic factors and
clinical diagnoses suggests that assessment of self-care behav-
iors may be necessary to explain the ability of these individu-
als to attain control of their conditions. Although our ability
to measure such behavioral characteristics was limited, med-
ication adherence emerged as a strong predictor of simultane-
ous control, whereas tobacco use and substance abuse were
unrelated to treatment outcomes. Assessment of the behavioral
strategies that these individuals use to facilitate their adherence
with medications or other elements of self-care will require
additional quantitative and qualitative research.

In summary, we found that in 2 large cohorts 16 to 30% of
individuals were able to achieve simultaneous, but generally
transient, control of diabetes mellitus, hypertension, and hyper-
lipidemia over a median of 4.0 to 4.4 years of follow-up. Small
changes in the treatment goals had a relatively large effect on
the proportion considered to be at goal. Efforts to understand
the strategies that such individuals, particularly those with
durable control, use to balance the demands of their multiple
health conditions may help define interventions to improve
self-care and health outcomes among the increasing population
of individuals with multiple, chronic health conditions.

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Disclosures
None.

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