

Original Investigation

Improved Blood Pressure Control Associated With a Large-Scale Hypertension Program

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IMPORTANCE Hypertension control for large populations remains a major challenge.

OBJECTIVE To describe a large-scale hypertension program in Northern California and to compare rates of hypertension control in that program with statewide and national estimates.

DESIGN, SETTING, AND PATIENTS The Kaiser Permanente Northern California (KPNC) hypertension program included a multifaceted approach to blood pressure control. Patients identified as having hypertension within an integrated health care delivery system in Northern California from 2001-2009 were included. The comparison group comprised insured patients in California between 2006-2009 who were included in the Healthcare Effectiveness Data and Information Set (HEDIS) commercial measurement by California health insurance plans participating in the National Committee for Quality Assurance (NCQA) quality measure reporting process. A secondary comparison group was included to obtain the reported national mean NCQA HEDIS commercial rates of hypertension control between 2001-2009 from health plans that participated in the NCQA HEDIS quality measure reporting process.

MAIN OUTCOMES AND MEASURES Hypertension control as defined by NCQA HEDIS.

RESULTS The KPNC hypertension registry included 349 937 patients when established in 2001 and increased to 652 763 by 2009. The NCQA HEDIS commercial measurement for hypertension control within KPNC increased from 43.6% (95% CI, 39.4%-48.6%) to 80.4% (95% CI, 75.6%-84.4%) during the study period ($P < .001$ for trend). In contrast, the national mean NCQA HEDIS commercial measurement increased from 55.4% to 64.1%. California mean NCQA HEDIS commercial rates of hypertension were similar to those reported nationally from 2006-2009 (63.4% to 69.4%).

CONCLUSIONS AND RELEVANCE Among adults diagnosed with hypertension, implementation of a large-scale hypertension program was associated with a significant increase in hypertension control compared with state and national control rates. Key elements of the program included a comprehensive hypertension registry, development and sharing of performance metrics, evidence-based guidelines, medical assistant visits for blood pressure measurement, and single-pill combination pharmacotherapy.

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Hypertension affects 65 million adults in the United States (29%)¹ and is a major contributor to cardiovascular disease.² Although effective therapies have been available for more than 50 years,³ fewer than half of Americans with hypertension had controlled blood pressure in 2001-2002.¹ Many quality improvement strategies for control of hypertension exist,⁴⁻¹⁰ but to date, no successful, large-scale program sustained over a long period has been described. A review of 72 clinical trials¹¹ identified several

ACE angiotensin-converting enzyme

HEDIS Healthcare Effectiveness Data and Information Set

SPC single-pill combination

interventions that improve blood pressure control in primary care settings, with the strongest evidence for an organized, comprehensive system of regular population review and intervention. Kaiser Permanente Northern California (KPNC) is a not-for-profit, integrated health care delivery system caring for more than 2.3 million adult members, with comprehensive inpatient and outpatient care provided through 21 hospitals, 45 medical facilities, and more than 7000 physicians. In 2001, KPNC developed a system-level, multifaceted quality improvement program for hypertension. We describe the details of the development and implementation of this program and its associated results for the period between 2001-2009.

Methods

KPNC Hypertension Program

The study was exempted from review by the Kaiser Foundation Research Institute's institutional review board. The KPNC hypertension quality improvement program included 5 major components.

Health System-Wide Hypertension Registry

In 2000, KPNC developed a large-scale program to improve blood pressure control. Patients with hypertension were identified quarterly using outpatient diagnostic codes, pharmacy data, and hospitalization records from health plan databases, and diagnoses were verified through chart review audits of random samples of identified members. Patients were included if they met any of the following: (1) 2 or more hypertension diagnoses coded in primary care visits in the prior 2 years, (2) 1 or more primary care hypertension diagnoses and 1 or more hospitalizations with a primary or secondary hypertension diagnosis in the prior 2 years, (3) 1 or more primary care hypertension diagnoses and 1 or more filled prescriptions for hypertension medication within the prior 6 months, or (4) 1 or more primary care hypertension diagnoses and 1 or more stroke-related hospitalizations or a history of coronary disease, heart failure, or diabetes mellitus. Per National Committee for Quality Assurance (NCQA) Healthcare Effectiveness Data and Information Set (HEDIS) specifications, patients were not included based on recorded blood pressure measurements alone.

Hypertension Control Rates

Kaiser Permanente Northern California reported annual hypertension control rates to the NCQA in accordance with HEDIS specifications.¹² The NCQA HEDIS definition was based on the blood pressure reading from the most recent visit with a reading during the measurement year (and after the diagnosis of hypertension was made). In KPNC, typical practice included blood pressure measurement by automated sphygmomanometers operated by trained medical assistants, with repeat measurements performed as needed by physicians using aneroid sphygmomanometers. A random sample of patient records was generated consisting of members aged 18 to 85 years (46-85 years before 2006) as of December 31 of the measurement year who were continuously enrolled and who had 1 or more hypertension diagnoses confirmed in the medical record on or before June 30 of that year. The number of sampled patient charts (305-411 per year) was determined by NCQA HEDIS specifications.¹² Individuals were excluded if they had end-stage renal disease, were pregnant, or had been admitted to a nonacute inpatient setting any time during the measurement year. The most recent outpatient, non-emergency department blood pressure measurement was used for the performance metric, excluding measurements taken during outpatient visits for the sole purpose of having diagnostic tests or surgical procedures performed (eg, sigmoidoscopy), obtained the same day as a major diagnostic or surgical procedure (eg, stress test, endoscopy), or patient self-reported values. Control was defined per NCQA HEDIS as both systolic blood pressure less than 140 mm Hg and diastolic blood pressure less than 90 mm Hg (≤ 140 mm Hg and ≤ 90 mm Hg before 2006). If multiple readings were recorded for a single date, the lowest systolic and lowest diastolic blood pressure was used as the representative blood pressure, but the systolic and diastolic results did not have to be from the same reading. If no blood pressure was recorded during the measurement year, the patient was classified as "not controlled."

In 2001, internal hypertension control reports were developed for quality improvement use, and performance measurements were designed that were similar to those of the NCQA HEDIS metric described above. However, unlike the NCQA HEDIS measurement, which included only a random sample of eligible individuals, the internal metric included all KPNC patients eligible for inclusion in the NCQA HEDIS hypertension control metric, ie, continuously enrolled members aged 18 to 85 years (46-85 years before 2006) as of December 31 of the measurement year, with documented hypertension in the medical record on or before June 30 of the measurement year. Patients were excluded from the internal hypertension control metric using the same criteria as the NCQA HEDIS commercial metric.

Hypertension control reports were generated every 1 to 3 months for each KPNC medical center and distributed to the center directors. During the study period, a central hypertension management team identified successful practices and disseminated effective strategies to the medical centers.

Table 1. Summary of Evidence-Based Clinical Practice Guideline for Initial Therapy and Treatment Intensification for the Kaiser Permanente Northern California Hypertension Program, by Year

Step	2001	2003	2005	2007	2009
1	Thiazide diuretic or β -blocker	Thiazide diuretic	Thiazide diuretic or thiazide diuretic + ACE inhibitor	Thiazide diuretic or thiazide diuretic + ACE inhibitor	Thiazide diuretic or thiazide diuretic + ACE inhibitor
2	Thiazide diuretic + β -blocker	Thiazide diuretic + ACE inhibitor or thiazide diuretic + β -blocker	Thiazide diuretic + ACE inhibitor	Thiazide diuretic + ACE inhibitor	Thiazide diuretic + ACE inhibitor
3	Thiazide diuretic + β -blocker + ACE inhibitor	Thiazide diuretic + β -blocker + ACE inhibitor	Thiazide diuretic + β -blocker + ACE inhibitor	Thiazide diuretic + β -blocker + ACE inhibitor	Thiazide diuretic + ACE inhibitor + DCCB
4	Thiazide diuretic + β -blocker + ACE inhibitor + DCCB	Thiazide diuretic + β -blocker + ACE inhibitor + DCCB	Thiazide diuretic + β -blocker + ACE inhibitor + DCCB	Thiazide diuretic + β -blocker + ACE inhibitor + DCCB	Thiazide diuretic + ACE inhibitor + DCCB + β -blocker or spironolactone

Abbreviations: ACE, angiotensin-converting enzyme; DCCB, dihydropyridine calcium channel blocker.

Table 2. Patient Characteristics of the Kaiser Permanente Northern California (KPNC) Hypertension Registry, 2001-2009

Year	%								
	2001	2002	2003	2004	2005	2006	2007	2008	2009
KPNC, No.									
Total adult population	2 278 043	2 345 910	2 325 616	2 339 898	2 384 895	2 421 141	2 423 368	2 416 095	2 371 761
Hypertension registry	349 937	415 687	432 611	509 783	543 650	572 100	600 523	610 724	652 763
Percentage of total KPNC adult membership	15.4	17.7	18.6	21.8	22.8	23.6	24.8	25.3	27.5
Age, mean (SD), y	63.0 (13.6)	63.0 (13.8)	62.9 (13.8)	63.0 (13.9)	63.0 (13.9)	62.9 (14.0)	63.0 (14.1)	63.3 (14.2)	63.0 (14.4)
Age category, y									
18-44	10.4	10.6	10.7	10.7	10.7	10.9	10.9	10.5	11.0
45-65	44.7	44.8	45.0	45.5	45.9	46.3	46.0	45.6	45.7
66-85	44.8	44.6	44.3	43.8	43.4	42.8	43.1	44.0	43.3
Women	52.1	52.2	52.3	52.4	52.3	52.2	52.2	52.3	52.7
Race/ethnicity									
White	NA	NA	NA	NA	NA	NA	NA	58.8	58.4
Black or African American	NA	NA	NA	NA	NA	NA	NA	10.6	10.8
Hispanic or Latino	NA	NA	NA	NA	NA	NA	NA	13.3	13.2
Asian or Pacific Islander	NA	NA	NA	NA	NA	NA	NA	16.1	16.5
Multiracial	NA	NA	NA	NA	NA	NA	NA	0.8	0.8
American Indian or Alaskan Native	NA	NA	NA	NA	NA	NA	NA	0.3	0.3
Diabetes mellitus	25.6	25.9	26.2	28.0	27.8	27.8	28.0	29.1	28.5

Abbreviations: KPNC, Kaiser Permanente Northern California; NA, not available.

Development of an Evidence-Based Practice Guideline

In 2001, an evidence-based, 4-step hypertension control algorithm was developed to aid clinicians (Table 1). The guideline was updated every 2 years based on emerging randomized trial evidence and national guidelines. Clinicians were encouraged to follow the algorithm unless clinical discretion required otherwise. Dissemination of guidelines occurred through distribution of printed documents, e-mail, clinical tools (eg, pocket cards), videoconferences, lectures, partnering with pharmacy managers, and use of the electronic medical record to optimize selection of medication.

Medical Assistant Visits for Follow-up Measurements

In 2007, all medical centers developed a medical assistant follow-up visit typically scheduled 2 to 4 weeks after a medication adjustment. Typically, a medical assistant measured blood pressure and informed the primary care physician, who then

directed treatment decisions and follow-up planning. Medical assistants were trained using standardized materials and blood pressure competency assessments. Patients were not charged a co-payment for these visits. This system accelerated treatment intensification without significantly increasing the need for repeat clinician visits, while simultaneously improving patient convenience and affordability.

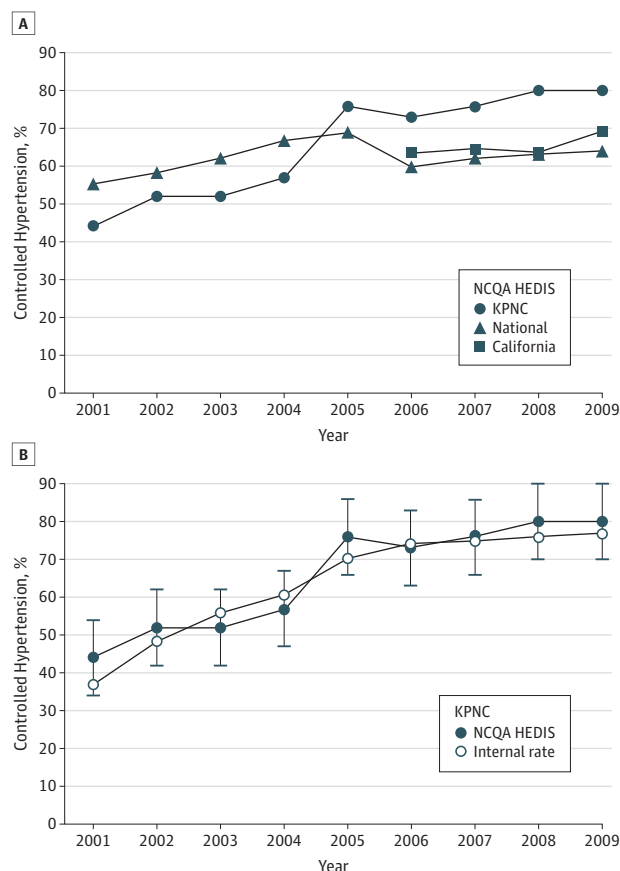
Promotion of Single-Pill Combination Therapy

In 2005, single-pill combination (SPC) therapy with lisinopril-hydrochlorothiazide was incorporated into the regional guideline as being optional for initial treatment and recommended as a step-2 strategy (Table 1).

Patient Characteristics

Information on demographic characteristics was available for patients in the hypertension registry (Table 2). Diabetes melli-

Figure 1. National Committee for Quality Assurance (NCQA) Healthcare Effectiveness Data and Information Set (HEDIS) Hypertension Control Rates



A, NCQA HEDIS hypertension control rates comparing Kaiser Permanente Northern California (KPNC), national, and California, 2001-2009. B, NCQA HEDIS hypertension control rates within KPNC vs KPNC internal hypertension registry control rates, 2001-2009. Error bars indicate 95% CIs for the KPNC NCQA HEDIS hypertension rates; 95% CIs for the KPNC internal hypertension registry control rates are not shown, because they are extremely small (<0.3%). See eTable (Supplement) for complete details.

tus was ascertained from a regional diabetes registry (see Appendix [Supplement] for details).¹³

Hypertension Control Rates

Control rate was defined as meeting the NCQA HEDIS commercial hypertension control criteria, an externally reported standard that permits comparison of rates across reporting health plans.¹² Using the same method, we report on KPNC hypertension registry control rates during the study period. We also examined publicly available national and California state commercial NCQA HEDIS control rates.¹² California data represented the mean control rate of commercial health insurance plans.

Statistical Analysis

Analyses were performed using SAS version 9.1 (SAS Institute Inc). Data were reported as means with standard deviations or frequencies and proportions. Comparisons across study

years were conducted using analysis of variance for continuous variables and χ^2 tests for categorical variables. Temporal trends for NCQA HEDIS hypertension control rates within KPNC were assessed using the Cochran-Armitage test. For annual control rates measured in the KPNC hypertension registry, we accounted for the nonindependence of proportions by treating as a time series, fitting a log-linear regression of the proportion on time, allowing for autocorrelated errors. All *P* values were 2-sided.

Results

Between 2001 and 2009, the KPNC hypertension registry increased from 349 937 (15.4% of adult KPNC membership) to 652 763 (27.5% of adult membership). The number of individuals used to calculate the internal hypertension control metric varied from 234 852 in 2001 to 353 156 in 2009. Among hypertension registry members, mean age was 63 (SD, 14) years; mean age remained stable throughout the study period, with the majority of patients aged 45 to 85 years (Table 2). More than half of registry members were women, and the proportion was similar across study years. Diabetes was common, and prevalence increased from 25.6% in 2001 to 28.5% in 2009.

The NCQA HEDIS commercial hypertension control rate within KPNC increased after implementation of the hypertension program from 43.6% (95% CI, 39.4%-48.6%) in 2001 to 80.4% (95% CI, 75.6%-84.4%) in 2009 (*P* < .001 for trend) (Figure 1A). Control rates calculated using the NCQA HEDIS metric and internal hypertension registry control metric were similar (*P* < .001 for trend) (Figure 1B). In contrast, the national mean NCQA HEDIS control rate increased from 55.4% to 64.1% between 2001 and 2009 (*P* = .24 for trend). California-wide control rates were available since 2006 and were similar but slightly higher than the national average (63.4% vs 69.4% from 2006 to 2009; *P* = .37 for trend).

In addition, following the study period, the NCQA HEDIS hypertension control rate within KPNC continued to improve, from 83.7% in 2010 to 87.1% in 2011.

From 2001 to 2009, the rate of lisinopril-hydrochlorothiazide SPC prescriptions in KPNC increased from 13 to 23 144 prescriptions per month. During this period, the percentage of angiotensin-converting enzyme (ACE) inhibitor prescriptions dispensed as an SPC (in combination with a thiazide diuretic) increased from less than 1% to 27.2% (Figure 2).

Discussion

Control of hypertension remains elusive nationally, despite widespread availability of effective therapies. Furthermore, limited data exist about the implementation and results of large, sustained hypertension programs. We describe a multifactorial approach implemented in one of the nation's largest community-based hypertension programs. This approach was associated with a near-doubling of hypertension control

between 2001 and 2009. In contrast, only modest improvements in hypertension control were observed statewide and nationally.

Our study is observational, and several facets of the hypertension program may have contributed to the improved hypertension control within our population. Creation of a comprehensive hypertension registry facilitated customizable queries to access clinically important data-enabled prioritization of patient subgroups (eg, poorly controlled hypertension) who were evaluated for appropriateness of treatment intensification. This is consistent with observations by Glynn et al,¹¹ who reported that the most effective intervention to improve blood pressure control in primary care settings is an organized system of regular population review rather than primarily patient- or clinician-focused interventions.

Regularly scheduled performance feedback delivered through quarterly and eventually monthly reports facilitated identification of high-performing medical centers in which successful practices or innovations were identified and then disseminated program-wide. Although feedback at the individual clinician level has long been used to promote change,¹⁴ we focused on clinic-level feedback to facilitate operational and system-level change.¹⁵

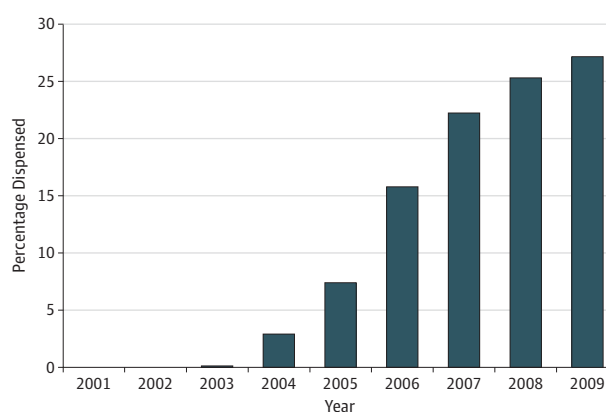
Health system-wide adoption, evaluation, and distribution of an evidence-based practice guideline that had timely incorporation of new evidence facilitated the ability to introduce new treatment options and to re-emphasize existing evidence-based recommendations.^{4,15,16} For example, β -blockers historically had an important role in management of hypertension and were an important part of early KPNC practice guidelines. As new evidence became available, the role of β -blockade in uncomplicated hypertension gradually diminished, and KPNC practice guidelines were revised accordingly.

Systematic medical assistant follow-up visits were designed to optimize workflow for clinicians while leveraging the skills of ancillary staff. These visits allowed patients greater access to the medical team by eliminating co-payments, allowing greater scheduling flexibility, and involving shorter visit times, all of which reduced patient barriers.^{4,17}

Use of lisinopril-hydrochlorothiazide SPC therapy was incorporated into KPNC practice guidelines in 2005, with subsequent rapid uptake system-wide. Single-pill combinations have important advantages, including improved adherence^{18,19} and lower patient cost,¹⁹ and are associated with improved blood pressure control.^{15,20-22}

It is not clear why in 2001 the NCQA HEDIS commercial control rate (43.6%) within KPNC was lower than the national control rate (55.4%). Possible explanations include lower actual control rates or underdiagnosis of milder disease. Also, because patients without a recorded blood pressure during the measurement year were considered as having uncontrolled hypertension, it may be that the portion of patients without a recorded blood pressure decreased during the study period. The higher NCQA HEDIS control rates within KPNC in 2005 relative to 2004 are likely attributable to variation in sampling, because NCQA HEDIS specifica-

Figure 2. Percentage of Angiotensin-Converting Enzyme Inhibitor Prescriptions Dispensed as Single-Pill Combination Angiotensin-Converting Enzyme Inhibitor-Hydrochlorothiazide Combination Tablets for Kaiser Permanente Northern California Members, 2001-2009



tions stipulate a relatively small sample size (ie, 305 to 411 patients) per measurement year, with attendant lower precision and greater year-to-year variability. There was a smaller increase in the internal control rate in 2005 based on a much larger denominator (ie, 234 852 to 353 156 patients) (Figure 1B). The decline in the mean national NCQA HEDIS control rate from 2005 to 2006 may in part be the result of the change in NCQA HEDIS reporting methodology for 2006. In 2006, NCQA changed the age of the HEDIS hypertension denominator from 46 to 85 years to 18 to 85 years and changed the blood pressure control threshold from 140/90 mm Hg or lower to lower than 140/90 mm Hg. Because the KPNC hypertension registry increased from 15.4% to 27.5% of the KPNC adult population during the study period, it is possible that the severity of hypertension within the registry decreased, although the prevalence was similar to that seen in the National Health and Nutrition Examination Survey (NHANES) (29.0%) in 2007-2008.¹ Furthermore, during the same period, the number of prescriptions per month for the most commonly used antihypertensive medications (ie, thiazide diuretics, ACE inhibitors, angiotensin receptor blockers, β -blockers, calcium channel blockers, and ACE inhibitors-thiazide diuretics as SPCs) increased in KPNC by 82%. Collectively, these data suggest that the apparent increase in hypertension reflects primarily improved detection and documentation of hypertension.

Comparison of demographic characteristics between patients used to determine the NCQA HEDIS control rates within KPNC and national or statewide NCQA HEDIS measures were not presented, because demographic NCQA HEDIS data from other health plans were not publicly reported. Although survey data were available and reviewed from California (California Health Interview Survey [CHIS]) and national (NHANES) sources, key methodological data acquisition differences precluded direct comparisons. KPNC data were collected for insured members using objective data documented in medical

records. In contrast, NHANES and CHIS survey data were collected from volunteers with and without health insurance, which may influence the sociodemographic composition of respondents, and relied on self-report to identify the presence of diabetes (NHANES and CHIS) and diagnosed hypertension (CHIS), with attendant concerns about significant misclassification contributing to apparent variation in prevalence of comorbid conditions. Census data from 2011 indicate that, compared with the nation, California residents were slightly younger, more likely to be Hispanic and Asian, and less likely to be white or black but had similar sex distribution.²³ However, these differences are unlikely to explain the large differences between KPNC control rates compared with California and national rates, because both the state and national average NCQA HEDIS control rates were similar and the KPNC population is highly representative of the statewide population, except for slightly lower representation at the extremes of age and income.^{24,25}

Comparisons of KPNC control rates with those from NHANES are also limited because of differences in the definition of controlled hypertension. KPNC rates were determined based on the standard NCQA HEDIS protocol using the most recent recorded outpatient blood pressure, which was the lowest recorded measurement on the day of examination, usually measured by a trained medical assistant using an automated sphygmomanometer. NHANES defined hypertension control based on blood pressure data measured by clinicians using mercury sphygmomanometers at a mobile examination center (using the mean of up to 3 blood pressure measurements during a single examination). Comparison of KPNC control rates with CHIS-derived California control rates is not possible because hypertension control was not a component of the CHIS survey.²⁶ Last, although patients with end-stage renal disease were excluded from the KPNC hypertension reg-

istry and control denominator in accordance with the NCQA HEDIS methodology, these patients comprised only 0.37% of the KPNC population, so the effects on overall hypertension control measures would be minimal.

In this observational study of a multifaceted intervention program, we cannot determine the degree to which individual components contributed to improved hypertension control or the role of other unidentified factors. Using the NCQA HEDIS commercial methodology facilitated comparisons against national and state estimates, but given that this approach relies on data from only a small subset of the overall hypertensive population, variations in year-to-year control estimates could be attributable to fluctuations in random sampling. The NCQA HEDIS commercial control rate is used nationally to compare hypertension control across health care organizations, so we cannot directly compare control rates from our larger internal hypertension registry with rates from other health care delivery systems. However, our internal hypertension registry control rates were very similar to our externally reported NCQA HEDIS commercial control rates, with the rates increasing similarly over time (Figure 1B). Our study extends reports from other large health care delivery systems that have also observed significant improvement in hypertension control. For example, the Veterans Affairs health care system reported improvements in hypertension control rates from 75% to 77% between 2006 and 2009.²⁷⁻²⁹

In summary, implementation of a large-scale hypertension program was associated with improvements in hypertension control rates between 2001 and 2009. Key elements of the program include establishment of a comprehensive hypertension registry, development and sharing of performance metrics, evidence-based guidelines, medical assistant visits for blood pressure measurement, and SPC pharmacotherapy.

ARTICLE INFORMATION

Author Contributions: Dr Jaffe had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Jaffe, Young, Lee, Go.

Acquisition of data: Jaffe, Lee.

Analysis and interpretation of data: All authors.

Drafting of the manuscript: All authors.

Critical revision of the manuscript for important intellectual content: All authors.

Statistical analysis: Lee, Sidney.

Obtained funding: Go.

Administrative, technical, or material support: Jaffe, Young, Lee, Sidney.

Study supervision: Jaffe, Lee.

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