Gaps in Dyslipidemia Care Among Working-Aged Individuals With Employer-Sponsored Health Care

Dov Shiffman, PhD; Judy Z. Louie, MSc; James J. Devlin, PhD; Joshua W. Knowles, MD; Michael J. McPhaul, MD

BACKGROUND: The American Heart Association and American College of Cardiology guidelines defined patient-management groups that would benefit from lowering of low-density lipoprotein cholesterol (LDL-C). We assessed gaps in dyslipidemia care among employees and spouses with health benefits.

METHODS AND RESULTS: We studied 17,889 employees and spouses who were covered by an employer-sponsored health plan and participated in an annual health assessment. Using medical claims, laboratory tests, and risk assessment questionnaires, we found that 43% of participants were in one of 4 patient-management groups: secondary prevention, severe hypercholesterolemia (LDL-C ≥190 mg/dL at least once in the preceding 5 years), diabetes mellitus, or elevated 10-year risk of cardiovascular disease. To assess gaps in dyslipidemia care, we used LDL-C ≤70 mg/dL as the goal for both the secondary prevention group and those in the elevated 10-year risk group with >20% risk; LDL-C ≤100 mg/dL was used for the other groups. Among those in patient-management groups, 27.3% were in the secondary prevention group, 7.4% were in the severe hypercholesterolemia group, 29.9% were in the diabetes mellitus group, and 35.4% were in the elevated 10-year risk group. About 74% of those in patient-management groups had above-goal LDL-C levels, whereas only 31% had evidence of a lipid-lowering therapy in the past 6 months: 45% in the secondary prevention group, 31% in the severe hypercholesterolemia group, 36% in the diabetes mellitus group, and 17% in the elevated 10-year risk group.

CONCLUSIONS: The substantial gaps in LDL-C treatment and goal attainment among members of an employer-sponsored medical plan who were mostly aware of their LDL-C levels indicate the need for gap-closure initiatives.

Key Words: cholesterol reduction ■ epidemiology ■ guideline adherence

MULTIPLE CLINICAL TRIALS HAVE FOUND THAT REDUCING low-density lipoprotein cholesterol (LDL-C) levels effectively prevents both primary and secondary cardiovascular disease (CVD) events. Relative risk reduction in these trials was ≈20% for each 40-mg/dL reduction of LDL-C.1,2 Therefore, achieving and maintaining LDL-C at or below goal has been a major emphasis of CVD prevention guidelines.3,4 Despite the well-recognized benefit of maintaining LDL-C levels at or below goal, elevated LDL-C levels remain a population health problem for a variety of reasons. Many adults who do not regularly visit a primary-care provider5 or may not be aware of their high LDL-C levels or elevated CVD risk.6 Even if LDL-C-lowering therapy is initiated, it may not be adjusted to achieve LDL-C at or below goal levels.7 Lack of periodic feedback from primary-care providers may also result in poor adherence to lipid-lowering therapy, and poor adherence has been shown to be associated with greater risk of dying.8 Gaps in dyslipidemia care have been reported among patients with established CVD,9-13 stroke,14 and peripheral artery disease15; in those with greater...
for treatment according to guidelines. These studies that include CVD risk assessment and lipid-level laboratory tests. Information collected in health assessment programs can be used to measure gaps in care targeting both patients and care providers seem warranted.

**What Are the Clinical Implications?**
- Dyslipidemia care is not appropriately managed even among individuals with access to medical care and who are aware of their cardiovascular health.
- Programs designed to improve dyslipidemia care targeting both patients and care providers seem warranted.

**Nonstandard Abbreviations and Acronyms**

| AHA | ACC | CVD | NHANES |
|-----|-----|-----|--------|
| American Heart Association | American College of Cardiology | cardiovascular disease | National Health and Nutrition Examination Survey |

numbers of CVD risk factors, and in those eligible for treatment according to guidelines. These studies were based on analyses of information limited to patients already under a physician's care, such as patient discharge records, patient registries, medical insurance claims or physician surveys. In addition, analyses based on national survey data do not consider the effect of the participants' medical insurance availability on lipid-lowering therapy utilization. We set out to assess gaps in dyslipidemia care in those who are members of a group health plan (who may or may not have a relationship with a healthcare provider) and who are likely to be aware of their cardiovascular health.

Many employers in the US offer annual employer-sponsored population health assessment programs that include CVD risk assessment and lipid-level laboratory tests. Information collected in health assessment programs can be used to measure gaps in care for working-aged populations with employer-provided health benefits.

We investigated the prevalence of above-goal LDL-C levels and the prevalence of lipid-lowering therapy among employees and spouses who were covered by an employer-sponsored health plan and participated in an annual health assessment offered by a US nationwide employer.

**METHODS**

The population of the study was drawn from 35,276 individuals who participated in an annual health assessment program between September 2017 and June 2018. The health assessment program was offered by a major US clinical diagnostics provider with employees in all 50 states to all its employees and their spouses. A majority of the workforce held jobs related to laboratory testing, phlebotomy, or sample-handling logistics. We excluded those who did not participate in the employer-sponsored group health plan for at least 12 consecutive months immediately before participating in the health screening program (n=10,709), those who were aged >75 or <40 years (n=6,433), and those with missing data (n=245). The remaining 17,889 participants were included in the analysis (Figure 1). An institutional review board waived the requirement for informed consent by determining that this research was conducted according to the Health Insurance Portability and Accountability Act (HIPAA) Privacy Rule, 45 CFR 164.514(e), which allows the use of retrospective limited data sets from which direct patient identifiers have been removed. The code developed for the statistical analysis in this article will be provided on request sent to the corresponding author. The data will not be available because distribution of limited data sets is limited by the HIPAA Privacy Rule.

The health assessment program included (1) measurement of blood pressure, height, and weight; (2) a health assessment questionnaire, including questions about smoking, diabetes mellitus status, and family history of myocardial infarction; and (3) a panel of laboratory tests performed on freshly drawn fasting blood samples including high-density lipoprotein cholesterol (HDL-C), LDL-C, total cholesterol, triglycerides, high-sensitivity C-reactive protein, glucose, hemoglobin A1c, and cotinine. Secondary prevention patients were identified based on the International Classification of Diseases, Ninth Revision (ICD-9) and ICD-10 codes in medical claims filed in the 12 months before health assessment program enrollment and up to 5 years before, if available. The ICD codes used to identify secondary prevention patients are listed in Table S1. The use of antihypertensive therapy and lipid-lowering therapy was defined as a pharmacy claim for a relevant therapy category (Tables S2 and S3) within the past 6 months or a self-reported use of therapy. Lipid-lowering
discontinuation was defined as a pharmacy claim for lipid-lowering therapy filed 7 to 12 months before health assessment program enrollment and up to 5 years before, if available, among those not using lipid-lowering therapy. Statin intensity was defined according to the 2018 American Heart Association and American College of Cardiology (AHA/ACC) guideline on the management of blood cholesterol.\(^3\)\(^,\)\(^4\) Diabetes mellitus was defined as having a fasting blood glucose level >125 mg/dL, hemoglobin A\(_1c\) >6.4%, a prescription for a diabetic medication in the past 6 months, or a self-reported physician diagnosis of diabetes mellitus. Hypertension was defined as having systolic blood pressure ≥140 mm Hg, diastolic blood pressure ≥90 mm Hg, antihypertensive medication prescription in the past 6 months, or a self-reported physician diagnosis of hypertension. Smoking status was defined as a positive cotinine test (>2 ng/mL) or self-reported smoking. Metabolic syndrome was defined using criteria reported in the 2018 AHA/ACC guideline on the management of blood cholesterol.\(^3\) The 10-year risk of CVD for participants without prevalent CVD was calculated using the pooled cohort equations.\(^20\)

Patient-management groups were defined according to the criteria in the 2013 and 2018 AHA/ACC guideline on the management of blood cholesterol.\(^3\)\(^,\)\(^4\) For this analysis, we placed patients in only 1 patient-management group. Patients who met the criteria for >1 group were placed in the first group for which they qualified in the following order: (1) the secondary prevention group (those with prevalent CVD), (2) the severe hypercholesterolemia group (those with LDL-C ≥190 mg/dL at least once in the preceding 5 years), (3) the diabetes mellitus group, and (4) the elevated 10-year risk of CVD group (>7.5% 10-year risk or >5% for those with at least 1 risk enhancer). In this study, risk enhancers were defined as LDL-C ≥160 mg/dL, estimated glomerular filtration rate <60 mL/min per 1.73 m\(^2\), triglycerides ≥175 mg/dL, high-sensitivity C-reactive protein ≥2 ng/L, or having a metabolic syndrome. LDL-C goals were defined as ≤70 mg/dL for the secondary prevention group and for those in the elevated 10-year risk group with >20% 10-year risk; LDL-C ≤100 mg/dL was used for the other groups, consistent with the AHA/ACC guideline on the management of blood cholesterol.\(^3\)

**Figure 1.** Study participants flow diagram. Horizontal arrows indicate exclusion from the study. Vertical arrows indicate flow of participants leading to final study population.

| 35 276 participants in an annual health assessment program between September 2017 and June 2018 |
| 10 709 did not participate in the employer-sponsored group health plan for at least 12 consecutive months immediately prior to participating in the health assessment program |
| 24 567 participants |
| 6433 were older than 75 or younger than 40 |
| 18 134 participants |
| 245 with missing data |
| 17 889 participants included in analysis |
Table. Characteristics of Study Population According to Patient-Management Group

| Characteristic                                      | Not in Patient-Management Group | Primary Prevention Groups | Secondary Prevention Group | P value* |
|-----------------------------------------------------|---------------------------------|---------------------------|----------------------------|----------|
|                                                     | n                               | Severe Hypercholesterolemia† | Diabetes Mellitus           | Elevated 10-y Risk of CVD |          |
|                                                     | 10 261                          | NA                        | 2277                       | 2702     | NA       |
| Achieve LDL-C goal (n)                              | NA                              | NA                        | 1075                       | 563      | NA       |
|                                                     | 50 (7)                          | 54 (7)                    | 9×10⁻³⁸                    | <1×10⁻¹⁰⁰ | 59 (7)    | <1×10⁻¹⁰⁰ | 57 (8)    | <1×10⁻¹⁰⁰ |
| Age, y, mean (SD)                                   | 75 (7)                          | 1319 (58)                 | 6×10⁻⁵                      | 882 (33) | <1×10⁻¹⁰⁰ | 1140 (55) | 5×10⁻⁴⁶   |
| Women, n (%)                                        | 7553 (74)                       | 54 (14)                   | 9×10⁻¹⁷                    | 49 (14)  | <1×10⁻¹⁰⁰ | 50 (15)  | 4×10⁻⁴⁵   |
| HDL-C, mg/dL, mean (SD)                             | 60 (18)                         | 101 (30)                  | 3×10⁻³⁷                    | 123 (26) | <1×10⁻¹⁰⁰ | 103 (34) | 3×10⁻¹⁶   |
| LDL-C, mg/dL, mean (SD)                             | 110 (28)                        | 171 (43)                  | <1×10⁻¹⁰⁰                  | 198 (32) | 2×10⁻³⁷   | 179 (40) | 3×10⁻¹³⁵  |
| TC, mg/dL, mean (SD)                                | 191 (33)                        | 253 (48)                  | 3×10⁻¹²⁰                   | 126 (92-176) | 126 (91-178) | <1×10⁻¹⁰⁰ | 111 (79-161) | 7×10⁻⁵⁵ |
| Triglycerides, mg/dL, median (IQR)                  | 93 (69-129)                     | 134 (99-184)              | 3×10⁻⁶⁰                    | 126 (92-176) | 126 (91-178) | <1×10⁻¹⁰⁰ | 111 (79-161) | 7×10⁻⁵⁵ |
| CRP, mg/L, mean (SD)                                | 3.2 (5.3)                       | 3.5 (4.7)                 | 0.1                        | 5.1 (8.2) | 3×10⁻³⁰   | 3.5 (4.9) | 2×10⁻³⁷   |
| Fasting glucose, mg/dL, mean (SD)                   | 92 (9)                          | 104 (36)                  | 5×10⁻¹⁴                    | 137 (51) | <1×10⁻¹⁰⁰ | 97 (10)  | 108 (36)  | 7×10⁻¹⁹   |
| HbA₁c, %, mean (SD)                                 | 53 (0.3)                        | 5.7 (1.2)                 | 5×10⁻¹⁶                    | 7.0 (1.5) | <1×10⁻¹⁰⁰ | 5.4 (0.3) | 8×10⁻⁸⁷   |
| SBP, mm Hg, mean (SD)                               | 120 (14)                        | 126 (16)                  | 6×10⁻³⁶                    | 128 (16) | 8×10⁻¹⁶   | 134 (15) | 127 (16)  | 3×10⁻⁶³   |
| DBP, mm Hg, mean (SD)                               | 76 (10)                         | 77 (11)                   | 3×10⁻³⁴                    | 78 (10)  | 2×10⁻³⁹   | 81 (10)  | 76 (10)   | 2×10⁻³⁴   |
| BMI, kg/m², mean (SD)                               | 28 (6)                          | 29 (6)                    | 0.04                       | 33 (8)   | <1×10⁻¹⁰⁰ | 30 (6)   | 7×10⁻³⁴   |
| Hypertension, n (%)                                 | 3241 (32)                       | 250 (44)                  | 8×10⁻¹⁰                    | 1688 (74) | 1×10⁻¹⁰⁰ | 1822 (67) | 1475 (71) | <1×10⁻¹⁰⁰ |
| Smoking, n (%)                                       | 816 (8)                         | 78 (14)                   | 2×10⁻⁶                     | 250 (11) | 3×10⁻⁶    | 603 (22) | 278 (13)  | 4×10⁻¹⁰⁰ |
| Diabetes mellitus, n (%)                            | 0 (0)                           | 79 (14)                   | NA                         | 2277 (100) | NA     | 0 (0)     | 593 (28)  | NA       |
| FH of MI, n (%)                                      | 1007 (10)                       | 65 (11)                   | 0.2                        | 324 (14) | 8×10⁻¹⁰   | 342 (13) | 2×10⁻⁶⁷   |

Between-group differences in continuous variables were assessed by Student t test, except for triglycerides for which Wilcoxon rank sum test was used. Differences in categorical variables were assessed by the χ² test. Continuous variables are presented as mean (SD), except for triglycerides, which are presented as median (IQR). Categorical variables are summarized by counts (percentage). BMI indicates body mass index; CRP, C-reactive protein; CVD, cardiovascular disease; DBP, diastolic blood pressure; FH, family history; HbA₁c, hemoglobin A₁c; HDL-C, high-density lipoprotein cholesterol; IQR, interquartile range; LDL-C, low-density lipoprotein cholesterol; MI, myocardial infarction; NA, not assessed; SBP, systolic blood pressure; and TC, total cholesterol.

*P values are for comparison to the first column (not in patient-management group).
†LDL-C ≥190 mg/dL at least once in the preceding 5 y.
cholesterol\textsuperscript{2} and the 2015 National Lipid Association Recommendations.\textsuperscript{21}

**Statistical Analysis**

Continuous baseline variables were summarized as mean±SD for normally distributed variables and as median and interquartile range otherwise. Categorical variables were summarized as count and percentage. Comparisons of continuous variables between groups were assessed by t test for normally distributed variables and by Wilcoxon rank sum test otherwise. Categorical variables were compared by $\chi^2$ test.

The 10-year risk of CVD at baseline was estimated using the pooled cohort equations.\textsuperscript{20} The 10-year survival, $S(t)$, where $t=10$, is $1-(10$-year risk of CVD). Assuming a constant hazard, the baseline hazard ($h_b$) was estimated as $h_b=[-\log_e S(10)]/10$. The 10-year risk of CVD after LDL-C lowering was estimated by considering the reported hazard ratio for LDL-C lowering as 0.79 for each 39 mg/dL (1.0 mmol/L) lowered.\textsuperscript{1,2} Therefore, the hazards after LDL-C lowering ($h_l$) were estimated as $h_l = h_b \times e^{-0.79 \times x}$, where $x$ is the difference in LDL-C at baseline and LDL-C level after lowering. The 10-year risk of CVD after LDL-C lowering was estimated from the hazard as $1-e^{-h \times t}$.

The projected CVD events after 10 years of follow-up at baseline and after LDL-C lowering were calculated from the means of the estimated 10-year risks at baseline and after LDL-C lowering, assuming exponential distribution of time to event with a constant hazard, $S(t)=e^{-(h \times t)}$, where $t=10$. Comparison of 10-year risk of CVD before and after LDL-C lowering was assessed by t test of the natural log–transformed difference in 10-year risk.

The difference between LDL-C levels in those with and without lipid-lowering therapy was evaluated by the Wilcoxon rank sum test. Comparisons among LDL-C goal achievement, lipid-lowering therapy, and lipid-lowering therapy discontinuation between women and men were assessed in logistic regression models adjusted for age. All analyses were performed in R software.\textsuperscript{22}

**RESULTS**

This cross-sectional study included 17 889 participants, of whom 7628 (43%) were in 1 of 4 patient-management groups: the secondary prevention group (27.3%, $n=2082$), the severe hypercholesterolemia group (LDL-C $\geq 190$ mg/dL at least once in the preceding 5 years; 7.4%, $n=567$), the diabetes mellitus group (29.9%, $n=2277$), and the elevated 10-year risk of CVD group (35.4%, $n=2702$). The remaining 10 261 participants were not in any patient-management group and, as expected, had lower levels of CVD risk factors than those in patient management groups (Table).

Only 26% of the participants in patient-management groups had LDL-C levels at or below goal. Of particular note, only 16% of those in the secondary prevention group were at or below LDL-C goal. A smaller fraction of women (11%) than men (22%) achieved LDL-C goals in this secondary prevention group ($P=5\times10^{-9}$; Figure 2A). The highest level of goal achievement (47% in women, 48% in men) was observed for those in the diabetes mellitus group. In both the primary and the secondary prevention groups, many participants with LDL-C levels above goal were young to middle-aged (Figure 3). In those above goal, 36% of men were younger than 55 years, and 60% of women were younger than 60.

Among women, the highest lipid-lowering therapy use was 46% in the diabetes mellitus group (Figure 2B). Among men, the highest lipid-lowering therapy use was observed in the secondary prevention group (64%). Men received lipid-lowering therapy more commonly than did women in the diabetes mellitus group and in the secondary prevention group ($P\leq 3\times10^{-5}$). The lipid-lowering therapy discontinuation rate ranged from a high of 26% among men in the secondary prevention group to 10% in men with elevated 10-year risk of CVD (Figure 2C). Those with self-reported family history of myocardial infarction were more likely to have evidence of lipid-lowering therapy (50.5%; 95% CI, 47.5–53.4%) than did those without family history (37.7%; 95% CI, 36.5–38.8%). In all patient-management groups, lipid-lowering therapy was more common in those with LDL-C level at or below goal than in those above goal (Figure 4). High-intensity statin therapy, which is recommended for all secondary-prevention patients, was evident in only 16% of those in the secondary-prevention patient-management group, and its use was even lower (ranging from 1% to 11%) in other patient-management groups.

In both the primary and secondary prevention groups, those using lipid-lowering therapy had lower LDL-C levels than did those who did not use therapy ($P<0.0001$; Figure 5). For the primary prevention groups, the median LDL-C level was 97 mg/dL (interquartile range: 79–120 mg/dL) among those who used lipid-lowering therapy (84% with a statin prescription) and 125 mg/dL among those who did not. Similarly, in the secondary prevention group, median LDL-C was 87 mg/dL (interquartile range: 69–109 mg/dL) among those who used lipid-lowering-therapy and 114 mg/dL among those who did not.

Lowering LDL-C levels to goal in the 3867 participants in the primary prevention groups with LDL-C levels above goal could almost double the fraction
of those with 10-year risk of CVD <5% from 16.2% to 30.2% (Figure 6) and could increase, by 36%, the fraction of those with 10-year risk <7.5% (from 39.5% to 53.7%). Overall, lowering LDL-C to goal would reduce the mean 10-year CVD risk to 8.6% from 10.6% (P < 0.0001). We estimate that reducing LDL-C to goal levels in the primary prevention groups would prevent about 20% of the CVD events projected to occur over the following 10 years (77 of the 408 projected CVD events).

**DISCUSSION**

In a working-aged population that was covered by a group health plan and participated in an annual health screen program, we found that LDL-C levels were above goal in about 74% of those in patient-management groups that could benefit from lipid-lowering therapy. Failure to reach goal was particularly common in the secondary prevention group (84%) and in the severe hypercholesterolemia group (93%; those with LDL-C ≥190 mg/dL at least once in any of the preceding 5 years). These gaps in care are surprising when we consider that 93% of the study population also participated in a health screening program in the prior year and thus were aware of their LDL-C levels and overall cardiovascular health status for at least 2 consecutive years and should have had an opportunity to address their elevated LDL-C levels.

More than 40% of participants were in patient-management groups—groups that would benefit from LDL-C lowering. The fraction of those in patient-management groups was similar to the 39% found in the offspring and third-generation cohorts of the Framingham Heart Study, but somewhat lower than the 49% found among US adults between the ages of 40 and 75 years in the 2005–2010 National Health and Nutrition Examination Survey (NHANES). The higher fraction found in NHANES may reflect
the roughly 10-year difference in the timing of the NHANES analysis and the current study, or it may be that the population of actively working employees with full medical benefits in the current study are simply healthier than the general population represented in NHANES.

About half of those in the secondary prevention and diabetes mellitus groups did not receive guideline-recommended lipid-lowering therapy. The fraction using lipid-lowering therapy was even lower in the severe hypercholesterolemia group and the elevated 10-year risk of CVD group—only 35% and 23%, respectively, of these groups were on lipid-lowering therapy (Figure 3). Our findings differ from an analysis of a cardiology practices registry (PINNACLE; National Cardiovascular Data Registry Practice Innovation and Clinical Excellence)25 that found most (about 68%) eligible patients receive lipid-lowering therapy; perhaps this difference is because all patients in the PINNACLE study were drawn from cardiology clinics and might have been more likely to receive cardiovascular care.

In the secondary prevention group, we found that the fraction receiving lipid-lowering therapy was substantially smaller for women than for men; perhaps consequently, a smaller fraction of women achieved the LDL-C goal for secondary prevention patients. However, lipid-lowering therapy discontinuation was less common among women than among men in the secondary prevention group; therefore, this

---

**Figure 3.** Age distribution in primary and secondary prevention groups.
Histograms of age for patients with low-density lipoprotein cholesterol (LDL-C) above goal in the primary prevention groups (A) and the secondary prevention group (B). Histograms are plotted for women (gray) and men (pink).

**Figure 4.** Lipid-lowering therapy type by patient-management group.
Fraction of patients in each patient-management group receiving high-, moderate-, or low-intensity statin therapy; other lipid-lowering therapy; or both statin and nonstatin therapy, according to low-density lipoprotein cholesterol (LDL-C) goal achievement.
discontinuation is unlikely to explain the lower therapy and goal achievement in women. This observation is consistent with an analysis of the 2011–2012 NHANES data that found a smaller fraction of women than men achieved LDL-C goals. The discontinuation rates we observed (10–26%) are consistent with the published discontinuation rate among 75-year-old primary prevention patients in France (14%) but lower than that reported in Japan. Statin discontinuation might be detrimental beyond its effect of LDL-C, and discontinuation has been reported to be associated with 33% increased risk of cardiovascular events in 75-year-old primary prevention patients. Similarly, in patients of the Veterans Administration System with CVD, low adherence to statin therapy was associated with mortality. Therefore, reduction or elimination of lipid-lowering therapy discontinuation in this population could improve health outcomes.

Our analyses also highlighted a potential underuse of nonstatin lipid-lowering therapy in those above goal, particularly in those in the secondary prevention group and in the severe hypercholesterolemia group (LDL-C ≥190 mg/dL at least once in the preceding 5 years). In these groups, >60% of the participants receiving high-intensity statin had LDL-C levels above goal. Although guidelines suggest considering the addition of ezetimibe to statin in these patients, only 3.8% had prescription for both statin and nonstatin therapy in those above goal in these 2 groups.

We estimated that reducing LDL-C to goal levels in the primary prevention groups would prevent about 20% of CVD events over the next 10 years in these groups. And given that many in these groups were young to middle-aged, lowering risk in this group should add a substantial number of quality-adjusted life-years to this population.

Although the study population was covered by an employer-sponsored group health plan and thus was less likely to have financial reasons for not receiving therapy than would the general population, we found gaps in LDL-C goal attainment and low rates of appropriate lipid-lowering therapy. This might be explained by the multiple steps that are required to effectively treat dyslipidemia: (1) the patient has to visit a healthcare provider, (2) the healthcare provider has to recognize the need for lipid-lowering therapy and provide a prescription, (3) the patient has to fill the prescription and begin to use the medication as prescribed, (4) the healthcare provider has to reevaluate the patient after initial prescription and adjust the prescription if needed, and (5) the patient

Figure 5. Low-density lipoprotein cholesterol (LDL-C) distribution. Histograms of LDL-C levels among patients in the primary prevention groups (A) and among patients in the secondary prevention group (B). Histograms are plotted for patients not receiving lipid-lowering therapy (LLT; red) and patients receiving LLT (green).

Figure 6. Ten-year risk of cardiovascular disease (CVD) in primary prevention groups. Fraction of patients with low (<5%) or moderately low (<7.5%) 10-year risk of CVD among those in the primary prevention groups who were above low-density lipoprotein cholesterol (LDL-C) goal (red) and aspirational fraction of patients in these groups (blue). The aspirational fractions were calculated by assuming LDL-C was lowered to goal. Error bars are 95% CIs. Number of patients in each fraction is indicated above bars.
might be considered. Wong et al, 18 for example, reported low LDL-C goal achievement in Hispanics and in those with history of stroke. Addressing gaps in dyslipidemia care will require programs that appropriately target steps that have the greatest impact on generating these gaps. To design effective programs, further investigation is needed to understand the causes and relative impact of failure at each step.

This study has several limitations related to potential incompleteness of medical claims data. For example, we likely underestimated the number of secondary prevention patients and the fraction who have discontinued their lipid-lowering therapy because, although we had access to medical claims from at least the 12 months before study initiation (and from up to the preceding 5 years for some), a longer record of claims for all participants would have likely identified more secondary prevention patients and more evidence of lipid-lowering therapy discontinuation. Similarly, the record of medication prescriptions in the 6 months before annual health screening participation could be incomplete if, for example, a patient obtained prescription medication outside the employer-sponsored program (eg, using a spouse insurance plan). We also did not have LDL-C test results if tests were not performed as part of the annual health screening program. Therefore, we might have underestimated the number of participants who had had severe hypercholesterolemia. Another limitation relates to the use of LDL-C goals in this study. Although the 2018 AHA/ACC guideline on the management of blood cholesterol set LDL-C goals for the secondary prevention and severe hypercholesterolemia groups, LDL-C reduction goals were set for other patient-management groups. Because this study is based on a single LDL-C assessment, we were unable to assess percentage of LDL-C reduction, and instead used clinically reasonable goals to assess goal attainment for all patient-management groups.

CONCLUSIONS

We have found substantial gaps in LDL-C treatment and goal attainment in working-aged employees and spouses with employer-sponsored medical plan and who were mostly aware of their LDL-C levels. Investigation into the causes of these gaps would help inform the design of gap-closure programs.

ARTICLE INFORMATION

Received December 31, 2019; accepted March 19, 2020.

Affiliations

From the Quest Diagnostics Nichols Institute, San Juan Capistrano, CA (D.S., J.Z.L., J.J.D., M.J.M.); Stanford Cardiovascular Medicine and Cardiovascular Institute and the FH Foundation, Stanford, CA (J.W.K.).

Sources of Funding

Knowles is supported by the Stanford Diabetes Research Center (P30DK116074), the Doris Duke Foundation, and the NIH through grant U41HG009649.

Disclosures

Shiffman, Louie, Devlin, and McPhaul are employees of Quest Diagnostics. Knowles has no disclosures to report.

Supplementary Materials

Tables S1–S3

REFERENCES

1. Cholesterol Treatment Trialists’ (CTT) Collaboration. The effects of lowering LDL cholesterol with statin therapy in people at low risk of vascular disease: meta-analysis of individual data from 27 randomised trials. Lancet. 2012;380:581–590.

2. Cholesterol Treatment Trialists’ (CTT) Collaboration. Efficacy and safety of LDL-lowering therapy among men and women: meta-analysis of individual data from 174,000 participants in 27 randomised trials. Lancet. 2015;385:1397–1405.

3. Grundy SM, Stone NJ, Bailey AL, Beam C, Birtcher KK, Blumenthal RS, Braun LT, de Ferranti S, Faiella-Tommasino J, Forman DE, et al. 2018 AHA/ACC/AACVPR/APA/ABC/ACPM/ADA/AGS/APhA/ASPC/NLA/PCNA guideline on the management of blood cholesterol. Circulation. 2019;139:e1082–e1143.

4. Stone NJ, Robinson JG, Lichtenstein AH, Bairey Merz CN, Blum CB, Eckel RH, Goldberg AC, Gordon D, Levy D, Lloyd-Jones DM, et al. American College of Cardiology/American Heart Association Task Force on Practice Guidelines. 2013 ACC/AHA guideline on the treatment of blood cholesterol to reduce atherosclerotic cardiovascular risk in adults: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. Circulation. 2014;129:S1–S45.

5. O’hara B, Caswell K. Health status, health insurance, and medical services utilization. Current Population Reports, 2010. Available at: www.census.gov/prod/2012pubs/p70-133.pdf. Accessed January 17, 2019.

6. Kibler JL, Ma M, Hrach J, Roas RA. Public knowledge of cardiovascular risk numbers: contextual factors affecting knowledge and health behavior, and the impact of public health campaigns. In: Watson RR, Zibadi S, eds. Lifestyle in Heart Health and Disease. Academic Press; 2018:11–20.

7. Goldberg KD, Meilink SD, Simek DL. Overcoming inertia: improvement in achieving target low-density lipoprotein cholesterol. Am J Manag Care. 2007;13:530–535.

8. Rodriguez F, Maron DJ, Knowles JW, Virani SS, Lin S, Heidenreich PA. Association of statin adherence with mortality in patients with atherosclerotic cardiovascular disease. JAMA Cardiol. 2019;4:206–213.

9. Okerson T, Patel J, DiMario S, Burton T, Seare J, Harrison DJ. Effect of 2013 ACC/AHA blood cholesterol guidelines on statin treatment patterns and low-density lipoprotein cholesterol in atherosclerotic cardiovascular disease patients. J Am Heart Assoc. 2017;6:e004909. DOI: 10.1161/JAHA.116.004909.

10. Rosenson RS, Kent ST, Brown TM, Farkouh ME, Lewtan EB, Yun H, Sharma P, Saiford MM, Kilgore M, Munter P, et al. Underutilization of high-intensity statin therapy after hospitalization for coronary heart disease. J Am Coll Cardiol. 2015;65:270–277.
11. Johansen ME, Green LA, Sen A, Kircher S, Richardson CR. Cardiovascular risk and statin use in the United States. Ann Fam Med. 2014;12:215–223.
12. Valentino M, Al Danaf J, Panakos A, Ragupathi L, Duffy D, Whellan D. Impact of the 2013 American College of Cardiology/American Heart Association cholesterol guidelines on the prescription of high-intensity statins in patients hospitalized for acute coronary syndrome or stroke. Am Heart J. 2016;181:130–136.
13. Arnold SV, Spertus JA, Tang F, Krumholz HM, Borden WB, Farmer SA, Ting HH, Chan PS. Statin use in outpatients with obstructive coronary artery disease. Circulation. 2011;124:2405–2410.
14. Ovbiagele B, Schwamm LH, Smith EE, Hernandez AF, Olson DM, Arnold SV, Spertus JA, Tang F, Krumholz HM, Borden WB, Farmer SA, Bhatt DL, Steg PG, Ohman EM, Hirsch AT, Ikeda Y, Mas JL, Goto S, Pande RL, Perlstein TS, Beckman JA, Creager MA. Secondary prevention and mortality in peripheral artery disease: National Health and Nutrition Examination Study, 1999 to 2004. Circulation. 2011;124:17–23.
15. Pande RL, Perlstein TS, Beckman JA, Creager MA. Secondary prevention and mortality in peripheral artery disease: National Health and Nutrition Examination Study, 1999 to 2004. Circulation. 2011;124:17–23.
16. Bhatt DL, Steg PG, Ohman EM, Hirsch AT, Ikeda Y, Mas JL, Goto S, Liu CS, Richard AJ, Rother J, et al. International prevalence, recognition, and treatment of cardiovascular risk factors in outpatients with atherothrombosis. JAMA. 2006;295:180–189.
17. Kelly KE, Jiroutek MR, Lewis K, Zagar B. Assessing changes in statin prescribing patterns surrounding the 2013 American College of Cardiology/American Heart Association lipid guidelines. Clin Ther. 2019;41:314–321.
18. Wong ND, Young D, Zhao Y, Nguyen H, Caballes J, Khan I, Sanchez RJ. Prevalence of the American College of Cardiology/American Heart Association statin eligibility groups, statin use, and low-density lipoprotein cholesterol control in US adults using the National Health and Nutrition Examination Survey 2011–2012. J Clin Lipidol. 2016;10:1109–1118.
19. Claxton G, Rae M, Long M, Panchal N, Damico A. Employer Health Benefits: 2016 Annual Survey. Menlo Park, CA: Henry J. Kaiser Family Foundation; 2016.
20. Goff DC Jr, Lloyd-Jones DM, Bennett G, Coady S, D’Agostino RB, Gibbons R, Greenland P, Lackland DT, Levy D, O’Donnell CJ, et al.; American College of Cardiology/American Heart Association Task Force on Practice G. 2013 ACC/AHA guideline on the assessment of cardiovascular risk: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. Circulation. 2014;129:S49–S73.
21. Jacobson TA, Ito MK, Maki KC, Orringer CE, Bays HE, Jones PH, McKenney JM, Grundy SM, Gill EA, Wild RA. National lipid association recommendations for patient-centered management of dyslipidemia: part 1—full report. J Clin Lipidol. 2015;9:129–169.
22. R Core Team. R: A Language and Environment for Statistical Computing. R Foundation for statistical computing: Vienna; 2012.
23. Pursnani A, Massaro JM, D’Agostino RB Sr, O’Donnell CJ, Hoffmann U. Guideline-based statin eligibility, coronary artery calcification, and cardiovascular events. JAMA. 2015;314:134–141.
24. Pencina MJ, Navar-Boggan AM, D’Agostino RB Sr, Williams K, Neely B, Sniderman AD, Peterson ED. Application of new cholesterol guidelines to a population-based sample. N Engl J Med. 2014;370:1422–1431.
25. Maddox TM, Borden WB, Tang F, Virani SS, Oetgen WJ, Mullen JB, Chan PS, Casale PN, Douglas PS, Masoudi FA, et al. Implications of the 2013 ACC/AHA cholesterol guidelines for adults in contemporary cardiovascular practice: insights from the NCDR PINNACLE Registry. J Am Coll Cardiol. 2014;64:2183–2192.
26. Gral P, Neumann A, Well A, Coote J. Cardiovascular effect of discontinuing statins for primary prevention at the age of 75 years: a nationwide population-based cohort study in France. Eur Heart J. 2019;40:3516–3525.
27. Nagar SP, Rane PP, Fox KM, Meyers J, Davis K, Beabrun A, Inomata H, Qian Y, Kajinami K. Treatment patterns, statin intolerance, and subsequent cardiovascular events among Japanese patients with high cardiovascular risk initiating statin therapy. Circ J. 2018;82:1008–1016.
28. Wake M, Oh A, Onishi Y, Guelfucci F, Shimasaki Y, Teramoto T. Adherence and persistence to hyperlipidemia medications in patients with atherosclerotic cardiovascular disease and those with diabetes mellitus based on administrative claims data in Japan. Atherosclerosis. 2019;282:19–28.
29. Jasińska-Stroschein M, Owczarek J, Wejman I, Orszulak-Michalak D. Novel mechanistic and clinical implications concerning the safety of statin discontinuation. Pharmacol Rep. 2011;63:867–879.
30. Cohen JD, Brinton EA, Ito MK, Jacobson TA. Understanding Statin Use in America and Gaps in Patient Education (USAGE): an internet-based survey of 10,138 current and former statin users. J Clin Lipidol. 2012;6:208–215.
31. Roaensin RS, Baker S, Banach M, Borow KM, Braun LT, Bruckert E, Brunham LR, Catapano AL, Elam MB, Mancini GBJ, et al. Optimizing cholesterol treatment in patients with muscle complaints. J Am Coll Cardiol. 2017;70:1290–1301.
32. Lewey J, Gagne JJ, Franklin J, Laufenburger JC, Brill G, Choudhry NK. Impact of high deductible health plans on cardiovascular medication adherence and health disparities. Circ Cardiovasc Qual Outcomes. 2018;11:e004632.
33. Wei MY, Ito MK, Cohen JD, Brinton EA, Jacobson TA. Predictors of statin adherence, switching, and discontinuation in the USAGE survey: understanding the use of statins in America and gaps in patient education. J Clin Lipidol. 2013;7:472–483.
34. Nielsen SF, Nordestgaard BG. Negative statin-related news stories decrease statin persistence and increase myocardial infarction and cardiovascular mortality: a nationwide prospective cohort study. Eur Heart J. 2016;37:908–916.
| ICD Type | ICD Code | Description |
|----------|----------|-------------|
| ICD-10-CM | G450 | Vertebro-basilar artery syndrome |
| ICD-10-CM | G451 | Carotid artery syndrome (hemispheric) |
| ICD-10-CM | G452 | Multiple and bilateral precerebral artery syndromes |
| ICD-10-CM | G453 | Amaurosis fugax |
| ICD-10-CM | G454 | Transient global amnesia |
| ICD-10-CM | G458 | Oth transient cerebral ischemic attacks and related synd |
| ICD-10-CM | G459 | Transient cerebral ischemic attack, unspecified |
| ICD-10-CM | I200 | Unstable angina |
| ICD-10-CM | I201 | Angina pectoris with documented spasm |
| ICD-10-CM | I208 | Other forms of angina pectoris |
| ICD-10-CM | I209 | Angina pectoris, unspecified |
| ICD-10-CM | I2102 | STEMI involving left anterior descending coronary artery |
| ICD-10-CM | I2109 | STEMI involving oth coronary artery of anterior wall |
| ICD-10-CM | I2111 | STEMI involving right coronary artery |
| ICD-10-CM | I2119 | STEMI involving oth coronary artery of inferior wall |
| ICD-10-CM | I2121 | STEMI involving left circumflex coronary artery |
| ICD-10-CM | I2129 | STEMI involving oth sites |
| ICD-10-CM | I213 | ST elevation (STEMI) myocardial infarction of unsp site |
| ICD-10-CM | I214 | Non-ST elevation (NSTEMI) myocardial infarction |
| ICD-10-CM | I219 | Acute myocardial infarction, unspecified |
| ICD-10-CM | I222 | Subsequent non-ST elevation (NSTEMI) myocardial infarction |
| ICD-10-CM | I240 | Acute coronary thrombosis not resulting in myocardial infrc |
| ICD-10-CM | I241 | Dressler's syndrome |
| ICD-10-CM | I248 | Other forms of acute ischemic heart disease |
| ICD-10-CM | I249 | Acute ischemic heart disease, unspecified |
| ICD-10-CM | I2510 | Athscl heart disease of native coronary artery w/o ang pctrs |
| ICD-10-CM | I25110 | Athscl heart disease of native cor art w unstable ang pctrs |
| ICD-10-CM | I25111 | Athscl heart disease of native cor art w ang pctrs w spasm |
| ICD-10-CM | I25118 | Athscl heart disease of native cor art w oth ang pctrs |
| ICD-10-CM | I25119 | Athscl heart disease of native cor art w unsp ang pctrs |
| ICD-10-CM | I252 | Old myocardial infarction |
| ICD-10-CM | I253 | Aneurysm of heart |
| ICD-10-CM | I2542 | Coronary artery dissection |
| ICD-10-CM | I255 | Ischemic cardiomyopathy |
| ICD-10-CM | I256 | silent myocardial ischemia |
| ICD-10-CM | I25700 | Atherosclerosis of coronary artery bypass graft(s), unspecified, with unstable angina pectoris |
| ICD-10-CM | I25708 | Atherosclerosis of CABG, unsp, w oth angina pectoris |
| ICD-10-CM | I25709 | Atherosclerosis of CABG, unsp, w unsp angina pectoris |
| ICD Type | ICD Code | Description |
|----------|----------|-------------|
| ICD-10-CM | I25710  | Athscl autologous vein CABG w unstable angina pectoris |
| ICD-10-CM | I25719  | Athscl autologous vein CABG w unsp angina pectoris |
| ICD-10-CM | I25790  | Atherosclerosis of CABG w unstable angina pectoris |
| ICD-10-CM | I25810  | Atherosclerosis of CABG w/o angina pectoris |
| ICD-10-CM | I25811  | Athscl native cor art of transplanted heart w/o ang pctrs |
| ICD-10-CM | I2582   | Chronic total occlusion of coronary artery |
| ICD-10-CM | I2583   | Coronary atherosclerosis due to lipid rich plaque |
| ICD-10-CM | I2584   | Coronary atherosclerosis due to calcified coronary lesion |
| ICD-10-CM | I2589   | Other forms of chronic ischemic heart disease |
| ICD-10-CM | I259    | Chronic ischemic heart disease, unspecified |
| ICD-10-CM | I609    | Nontraumatic subarachnoid hemorrhage, unspecified |
| ICD-10-CM | I610    | Nontraumatic intrcbl hemorrhage in hemisphere, subcortical |
| ICD-10-CM | I611    | Nontraumatic intrcbl hemorrhage in hemisphere, cortical |
| ICD-10-CM | I612    | Nontraumatic intracerebral hemorrhage in hemisphere, unsp |
| ICD-10-CM | I615    | Nontraumatic intracerebral hemorrhage, intraventricular |
| ICD-10-CM | I619    | Nontraumatic intracerebral hemorrhage, unspecified |
| ICD-10-CM | I6200   | Nontraumatic subdural hemorrhage, unspecified |
| ICD-10-CM | I6201   | Nontraumatic acute subdural hemorrhage |
| ICD-10-CM | I6202   | Nontraumatic subacute subdural hemorrhage |
| ICD-10-CM | I6203   | Nontraumatic chronic subdural hemorrhage |
| ICD-10-CM | I629    | Nontraumatic intracranial hemorrhage, unspecified |
| ICD-10-CM | I63011  | Cerebral infarction due to thrombosis of r verteb art |
| ICD-10-CM | I6309   | Cerebral infarction due to thrombosis of precerebral artery |
| ICD-10-CM | I6310   | Cerebral infarction due to embolism of unsp precerb artery |
| ICD-10-CM | I63112  | Cerebral infarction due to embolism of left vertebral artery |
| ICD-10-CM | I63132  | Cerebral infarction due to embolism of left carotid artery |
| ICD-10-CM | I63139  | Cerebral infarction due to embolism of unsp carotid artery |
| ICD-10-CM | I6320   | Cereb infrc due to unsp ocls or stenos of unsp precerb art |
| ICD-10-CM | I63211  | Cerebral infrc due to unsp ocls or stenos of r verteb art |
| ICD-10-CM | I63212  | Cerebral infrc due to unsp ocls or stenos of l verteb art |
| ICD-10-CM | I63231  | Cereb infrc due to unsp ocls or stenos of right carotid art |
| ICD-10-CM | I63232  | Cereb infrc due to unsp ocls or stenos of left carotid art |
| ICD-10-CM | I63239  | Cereb infrc due to unsp ocls or stenos of unsp carotid art |
| ICD-10-CM | I6330   | Cerebral infarction due to thrombos unsp cerebral artery |
| ICD-10-CM | I63311  | Cereb infrc due to thrombos of right middle cerebral artery |
| ICD-10-CM | I63312  | Cerebral infrc due to thrombos of left middle cerebral artery |
| ICD-10-CM | I63319  | Cerebral infrc due to thrombos unsp middle cerebral artery |
| ICD-10-CM | I63332  | Cerebral infrc due to thrombos of left post cerebral artery |
| ICD-10-CM | I6340   | Cerebral infarction due to embolism of unsp cerebral artery |
| ICD-10-CM | I63411  | Cereb infrc due to embolism of right middle cerebral artery |
| ICD-10-CM | I63412  | Cereb infrc due to embolism of left middle cerebral artery |
| ICD-10-CM | I63421  | Cereb infrc due to embolism of right ant cerebral artery |
| ICD-10-CM | I63432  | Cerebral infrc due to embolism of left post cerebral artery |
| ICD Type  | ICD Code   | Description                                                                 |
|-----------|------------|-----------------------------------------------------------------------------|
| ICD-10-CM | I6349      | Cerebral infarction due to embolism of other cerebral artery                |
| ICD-10-CM | I6350      | Cerebral infarction due to unsp ocss or sten of unsp cereb artery          |
| ICD-10-CM | I63511     | Cerebral infarction d/t unsp ocss or sten of right mid cereb art           |
| ICD-10-CM | I63512     | Cerebral infarction d/t unsp ocss or sten of left mid cereb art            |
| ICD-10-CM | I63531     | Cerebral infarction d/t unsp ocss or sten of right post cereb art          |
| ICD-10-CM | I63532     | Cerebral infarction d/t unsp ocss or sten of left post cereb art           |
| ICD-10-CM | I63541     | Cerebral infarction due to unsp ocss or sten of right cereblr art          |
| ICD-10-CM | I63542     | Cerebral infarction due to unsp ocss or sten of left cereblr art           |
| ICD-10-CM | I6359      | Cerebral infarction due to unsp ocss or stenosis of cerebral artery        |
| ICD-10-CM | I638       | Other cerebral infarction                                                   |
| ICD-10-CM | I639       | Cerebral infarction, unspecified                                           |
| ICD-10-CM | I6501      | Occlusion and stenosis of right vertebral artery                            |
| ICD-10-CM | I6502      | Occlusion and stenosis of left vertebral artery                             |
| ICD-10-CM | I6503      | Occlusion and stenosis of bilateral vertebral arteries                     |
| ICD-10-CM | I6509      | Occlusion and stenosis of unspecified vertebral artery                     |
| ICD-10-CM | I6521      | Occlusion and stenosis of right carotid artery                              |
| ICD-10-CM | I6522      | Occlusion and stenosis of left carotid artery                               |
| ICD-10-CM | I6523      | Occlusion and stenosis of bilateral carotid arteries                        |
| ICD-10-CM | I6529      | Occlusion and stenosis of unspecified carotid artery                       |
| ICD-10-CM | I658       | Occlusion and stenosis of other precerebral arteries                       |
| ICD-10-CM | I6601      | Occlusion and stenosis of right middle cerebral artery                     |
| ICD-10-CM | I6602      | Occlusion and stenosis of left middle cerebral artery                      |
| ICD-10-CM | I6613      | Occlusion and stenosis of bi anterior cerebral arteries                    |
| ICD-10-CM | I668       | Occlusion and stenosis of other cerebral arteries                           |
| ICD-10-CM | I669       | Occlusion and stenosis of unspecified cerebral artery                      |
| ICD-10-CM | I670       | Dissection of cerebral arteries, nonruptured                               |
| ICD-10-CM | I671       | Cerebral aneurysm, nonruptured                                             |
| ICD-10-CM | I672       | Cerebral atherosclerosis                                                   |
| ICD-10-CM | I674       | Hypertensive encephalopathy                                                |
| ICD-10-CM | I675       | Moyamoya disease                                                           |
| ICD-10-CM | I676       | Nonpyogenic thrombosis of intracranial venous system                       |
| ICD-10-CM | I6781      | Acute cerebrovascular insufficiency                                         |
| ICD-10-CM | I6782      | Cerebral ischemia                                                          |
| ICD-10-CM | I67848     | Other cerebrovascular vasospasm and vasoconstriction                       |
| ICD-10-CM | I6789      | Other cerebrovascular disease                                              |
| ICD-10-CM | I679       | Cerebrovascular disease, unspecified                                       |
| ICD-10-CM | I69053     | Hemiplega following ntrm subarach hemor aff right nondom side              |
| ICD-10-CM | I69054     | Hemiplega following ntrm subarach hemor aff left nondom side               |
| ICD-10-CM | I6910      | Unsp sequelae of nontraumatic intracerebral hemorrhage                     |
| ICD-10-CM | I6911      | Cognitive deficits following nontrau (Invalid, Non-Billable)               |
| ICD-10-CM | I69154     | Hemiplega following ntrm interbl hemor aff left nondom side                |
| ICD-10-CM | I6921      | Cognitive deficits following oth ntr (Invalid, Non-Billable)               |
| ICD-10-CM | I69291     | Dysphagia following oth nontraumatic intracranial hemorrhage               |
| ICD Type | ICD Code | Description |
|----------|----------|-------------|
| ICD-10-CM | I6930  | Unspecified sequelae of cerebral infarction |
| ICD-10-CM | I6931  | Cognitive deficits following cerebra (Invalid, Non-Billable) |
| ICD-10-CM | I69310 | Attention and concentration deficit following cerebral infarction |
| ICD-10-CM | I69311 | Memory deficit following cerebral infarction |
| ICD-10-CM | I69320 | Aphasia following cerebral infarction |
| ICD-10-CM | I69321 | Dysphasia following cerebral infarction |
| ICD-10-CM | I69322 | Dysarthria following cerebral infarction |
| ICD-10-CM | I69328 | Oth speech/lang deficits following cerebral infarction |
| ICD-10-CM | I69331 | Monoplg upr lmb fol cerebral infarc aff right dominant side |
| ICD-10-CM | I69341 | Monoplg low lmb fol cerebral infarc aff right dominant side |
| ICD-10-CM | I69351 | Hemiplga following cerebral infarc aff right dominant side |
| ICD-10-CM | I69352 | Hemiplga following cerebral infarc aff left dominant side |
| ICD-10-CM | I69354 | Hemiplga following cerebral infarc affecting left nondom side |
| ICD-10-CM | I69359 | Hemiplga following cerebral infarction affecting unsp side |
| ICD-10-CM | I69391 | Dysphagia following cerebral infarction |
| ICD-10-CM | I69392 | Facial weakness following cerebral infarction |
| ICD-10-CM | I69393 | Ataxia following cerebral infarction |
| ICD-10-CM | I69398 | Other sequelae of cerebral infarction |
| ICD-10-CM | I6981  | Cognitive deficits following other c (Invalid, Non-Billable) |
| ICD-10-CM | I69820 | Aphasia following other cerebrovascular disease |
| ICD-10-CM | I69854 | Hemiplga fol oth cerebvasc disease aff left nondom side |
| ICD-10-CM | I69859 | Hemiplga following oth cerebvasc disease aff unsp side |
| ICD-10-CM | I69898 | Other sequelae of other cerebrovascular disease |
| ICD-10-CM | I6990  | Unspecified sequelae of unspecified cerebrovascular disease |
| ICD-10-CM | I69920 | Aphasia following unspecified cerebrovascular disease |
| ICD-10-CM | I69928 | Oth speech/lang deficits following unsp cerebvasc disease |
| ICD-10-CM | I69953 | Hemiplga fol unsp cerebvasc disease aff right nondom side |
| ICD-10-CM | I69959 | Hemiplga following unsp cerebvasc disease aff unsp side |
| ICD-10-CM | I69991 | Dysphagia following unspecified cerebrovascular disease |
| ICD-10-CM | I69993 | Ataxia following unspecified cerebrovascular disease |
| ICD-10-CM | I69998 | Other sequelae following unspecified cerebrovascular disease |
| ICD-10-CM | I720  | Aneurysm of carotid artery |
| ICD-10-CM | I722  | Aneurysm of renal artery |
| ICD-10-CM | I723  | Aneurysm of iliac artery |
| ICD-10-CM | I724  | Aneurysm of artery of lower extremity |
| ICD-10-CM | I728  | Aneurysm of other specified arteries |
| ICD-10-CM | I729  | Aneurysm of unspecified site |
| ICD-10-CM | I7300 | Raynaud's syndrome without gangrene |
| ICD-10-CM | I7301 | Raynaud's syndrome with gangrene |
| ICD-10-CM | I731  | Thromboangiitis obliterans [Buerger's disease] |
| ICD-10-CM | I7389 | Other specified peripheral vascular diseases |
| ICD-10-CM | I739  | Peripheral vascular disease, unspecified |
| ICD-10-CM | Z950  | Presence of cardiac pacemaker |
| ICD Type | ICD Code | Description |
|----------|----------|-------------|
| ICD-10-CM | Z951 | Presence of aortocoronary bypass graft |
| ICD-10-CM | Z952 | Presence of prosthetic heart valve |
| ICD-10-CM | Z953 | Presence of xenogenic heart valve |
| ICD-10-CM | Z954 | Presence of other heart-valve replacement |
| ICD-10-CM | Z955 | Presence of coronary angioplasty implant and graft |
| ICD-10-CM | Z95810 | Presence of automatic (implantable) cardiac defibrillator |
| ICD-10-CM | Z95818 | Presence of other cardiac implants and grafts |
| ICD-10-CM | Z95820 | Peripheral vascular angioplasty status w implants and grafts |
| ICD-10-CM | Z95828 | Presence of other vascular implants and grafts |
| ICD-10-CM | Z959 | Presence of cardiac and vascular implant and graft, unsp |
| ICD-10-PCS | _0210099 | Bypass 1 Cor Art from L Int Mammary w Autol Vn, Open |
| ICD-10-PCS | _021009W | Bypass 1 Cor Art from Aorta with Autol Vn, Open Approach |
| ICD-10-PCS | _02100A8 | Bypass 1 Cor Art from R Int Mammary w Autol Art, Open |
| ICD-10-PCS | _02100A9 | Bypass 1 Cor Art from L Int Mammary w Autol Art, Open |
| ICD-10-PCS | _02100AW | Bypass 1 Cor Art from Aorta with Autol Art, Open Approach |
| ICD-10-PCS | _02100Z8 | Bypass 1 Cor Art from R Int Mammary, Open Approach |
| ICD-10-PCS | _02100Z9 | Bypass 1 Cor Art from L Int Mammary, Open Approach |
| ICD-10-PCS | _021109W | Bypass 2 Cor Art from Aorta with Autol Vn, Open Approach |
| ICD-10-PCS | _02110A3 | Bypass 2 Cor Art from Cor Art with Autol Art, Open Approach |
| ICD-10-PCS | _021209W | Bypass 3 Cor Art from Aorta with Autol Vn, Open Approach |
| ICD-10-PCS | _0213093 | Bypass 4+ Cor Art from Cor Art with Autol Vn, Open Approach |
| ICD-10-PCS | _0270346 | Dilate 1 Cor Art, Bifurc, w Drug-elut Intra, Perc |
| ICD-10-PCS | _027034Z | Dilation of 1 Cor Art with Drug-elut Intra, Perc Approach |
| ICD-10-PCS | _027036Z | Dilation of 1 Cor Art with 3 Drug-elut, Perc Approach |
| ICD-10-PCS | _02703DZ | Dilation of 1 Cor Art with Intralum Dev, Perc Approach |
| ICD-10-PCS | _02703Z6 | Dilation of 1 Cor Art, Bifurc, Perc Approach |
| ICD-10-PCS | _02703ZZ | Dilation of Coronary Artery, One Artery, Perc Approach |
| ICD-10-PCS | _027134Z | Dilation of 2 Cor Art with Drug-elut Intra, Perc Approach |
| ICD-10-PCS | _0271356 | Dilate of 2 Cor Art, Bifurc, with 2 Drug-elut, Perc Approach |
| ICD-10-PCS | _027135Z | Dilation of 2 Cor Art with 2 Drug-elut, Perc Approach |
| ICD-10-PCS | _0272346 | Dilate 3 Cor Art, Bifurc, w Drug-elut Intra, Perc |
| ICD-10-PCS | _027234Z | Dilation of 3 Cor Art with Drug-elut Intra, Perc Approach |
| ICD-9-CM | 412 | OLD MYOCARDIAL INFARCT |
| ICD-9-CM | 430 | SUBARACHNOID HEMORRHAGE |
| ICD-9-CM | 431 | INTRACEREBRAL HEMORRHAG |
| ICD-9-CM | 436 | Acute, but ill-defined, cerebrovascular disease |
| ICD-9-CM | 3950 | RHEUMAT AORTIC STENOSIS |
| ICD-9-CM | 4100 | Acute myocardial infarction of anterolateral wall |
| ICD-9-CM | 4104 | Acute myocardial infarction of other inferior wall |
| ICD-9-CM | 4107 | Subendocardial infarction |
| ICD-9-CM | 4110 | POST MI SYNDROME |
| ICD-9-CM | 4111 | INTERMED CORONARY SYND |
| ICD-9-CM | 4130 | ANGINA DECUBITUS |
| ICD Type | ICD Code | Description |
|----------|----------|-------------|
| ICD-9-CM | 4131     | PRINZMETAL ANGINA |
| ICD-9-CM | 4139     | ANGINA PECTORIS NEC/NOS |
| ICD-9-CM | 4140     | Coronary atherosclerosis |
| ICD-9-CM | 4141     | Aneurysm and dissection of heart |
| ICD-9-CM | 4142     | CHR TOT OCCLUS COR ARTR |
| ICD-9-CM | 4143     | COR ATH D/T LPD RCH PLA |
| ICD-9-CM | 4144     | COR ATH D/T CALC COR LS |
| ICD-9-CM | 4148     | CHR ISCHEMIC HRT DIS NE |
| ICD-9-CM | 4149     | CHR ISCHEMIC HRT DIS NO |
| ICD-9-CM | 4321     | SUBDURAL HEMORRHAGE |
| ICD-9-CM | 4329     | INTRACRANIAL HEMORR NOS |
| ICD-9-CM | 4331     | Occlusion and stenosis of carotid artery |
| ICD-9-CM | 4333     | Occlusion and stenosis of multiple and bilateral precerebral arteries |
| ICD-9-CM | 4350     | BASILAR ARTERY SYNDROME |
| ICD-9-CM | 4351     | VERTEBRAL ARTERY SYNDRO |
| ICD-9-CM | 4352     | SUBCLAVIAN STEAL SYNDRO |
| ICD-9-CM | 4353     | VERTBROBASLR ARTERY SYN |
| ICD-9-CM | 4358     | TRANS CEREB ISCHEMIA NE |
| ICD-9-CM | 4359     | TRANS CEREB ISCHEMIA NO |
| ICD-9-CM | 4370     | CEREBRAL ATHHEROSCLEROSI |
| ICD-9-CM | 4371     | AC CEREBROVASC INSUF NO |
| ICD-9-CM | 4372     | HYPERTENS ENCEPHALOPATH |
| ICD-9-CM | 4373     | NONRUPT CEREBRAL ANEURY |
| ICD-9-CM | 4375     | MOYAMOYA DISEASE |
| ICD-9-CM | 4376     | NONPYOGEN THROMBOS SINU |
| ICD-9-CM | 4377     | TRANSIENT GLOBAL AMNESI |
| ICD-9-CM | 4378     | CEREBROVASC DISEASE NEC |
| ICD-9-CM | 4379     | CEREBROVASC DISEASE NOS |
| ICD-9-CM | 4380     | LATE EF CV DIS-COGRF DE |
| ICD-9-CM | 4384     | Monoplegia of lower limb |
| ICD-9-CM | 4386     | ALTERATION OF SENSATION |
| ICD-9-CM | 4387     | DISTURBANCES OF VISION |
| ICD-9-CM | 4389     | LATE EFFECT CV DIS NOS |
| ICD-9-CM | 4419     | AORTIC ANEURYSM NOS |
| ICD-9-CM | 4439     | PERIPH VASCULAR DIS NOS |
| ICD-9-CM | 25070    | DMII CIRC NT ST UNCNTRL |
| ICD-9-CM | 25071    | DMI CIRC NT ST UNCNTRLD |
| ICD-9-CM | 25072    | DMII CIRC UNCNTRLD |
| ICD-9-CM | 25073    | DMI CIRC UNCNTRLD |
| ICD-9-CM | 41000    | AMI ANTEROLATERAL,UNSPE |
| ICD-9-CM | 41001    | AMI ANTEROLATERAL, INIT |
| ICD-9-CM | 41010    | AMI ANTERIOR WALL,UNSPE |
| ICD-9-CM | 41011    | AMI ANTERIOR WALL, INIT |
| ICD Type | ICD Code | Description                        |
|----------|----------|------------------------------------|
| ICD-9-CM | 41012    | AMI ANTERIOR WALL, SUBSEQUENT       |
| ICD-9-CM | 41020    | AMI INFEROLATERAL, UNSPECIFIED     |
| ICD-9-CM | 41021    | AMI INFEROLATERAL, INITIAL         |
| ICD-9-CM | 41030    | AMI INFEROPOST, UNSPECIFIED        |
| ICD-9-CM | 41031    | AMI INFEROPOST, INITIAL            |
| ICD-9-CM | 41040    | AMI INFERIOR WALL, UNSPECIFIED     |
| ICD-9-CM | 41041    | AMI INFERIOR WALL, INITIAL         |
| ICD-9-CM | 41042    | AMI INFERIOR WALL, SUBSEQUENT      |
| ICD-9-CM | 41051    | AMI LATERAL NEC, INITIAL           |
| ICD-9-CM | 41060    | TRUE POST INFARCT, UNSPECIFIED     |
| ICD-9-CM | 41061    | TRUE POST INFARCT, INITIAL         |
| ICD-9-CM | 41070    | SUBENDO INFARCT, UNSPECIFIED       |
| ICD-9-CM | 41071    | SUBENDO INFARCT, INITIAL           |
| ICD-9-CM | 41072    | SUBENDO INFARCT, SUBSEQUENT        |
| ICD-9-CM | 41080    | AMI NEC, UNSPECIFIED               |
| ICD-9-CM | 41081    | AMI NEC, INITIAL                   |
| ICD-9-CM | 41082    | AMI NEC, SUBSEQUENT                |
| ICD-9-CM | 41090    | AMI NOS, UNSPECIFIED               |
| ICD-9-CM | 41091    | AMI NOS, INITIAL                   |
| ICD-9-CM | 41092    | AMI NOS, SUBSEQUENT                |
| ICD-9-CM | 41181    | ACUTE COR OCCLUSIONS W/O MI        |
| ICD-9-CM | 41189    | AC ISCHEMIC HRT DISSEC            |
| ICD-9-CM | 41400    | COR ATH UNSP VSL NTG/VE            |
| ICD-9-CM | 41401    | CRNRY ATHRSC NATVE VSS             |
| ICD-9-CM | 41402    | CRN ATH ATLG VN BPS GRF           |
| ICD-9-CM | 41404    | COR ATH ARTRY BYPASS GRF          |
| ICD-9-CM | 41405    | COR ATH BYPASS GRAFT NO           |
| ICD-9-CM | 41406    | COR ATH NATVE ART TP HRT          |
| ICD-9-CM | 41407    | COR ATH BPS GRAFT TP HRT          |
| ICD-9-CM | 41410    | ANEURYSM OF HEART                 |
| ICD-9-CM | 41411    | ANEURYSM CORONARY VESSE           |
| ICD-9-CM | 41412    | DISSECTION COR ARTERY             |
| ICD-9-CM | 43300    | OCL BSLR ART WO INFARCT           |
| ICD-9-CM | 43310    | OCL CRTD ART WO INFARCT           |
| ICD-9-CM | 43311    | OCL CRTD ART W INFARCT            |
| ICD-9-CM | 43320    | OCL VRTB ART WO INFARCT           |
| ICD-9-CM | 43321    | OCL VRTB ART W INFARCT            |
| ICD-9-CM | 43330    | OCL MLT BI ART WO INFARCT         |
| ICD-9-CM | 43331    | OCL MLT BI ART W INFARCT          |
| ICD-9-CM | 43380    | OCL SPCEF ART WO INFARCT          |
| ICD-9-CM | 43381    | OCL SPCEF ART W INFARCT           |
| ICD-9-CM | 43390    | OCL ART NOS WO INFARCT            |
| ICD-9-CM | 43391    | OCL ART NOS W INFARCT             |
| ICD Type | ICD Code | Description                      |
|----------|----------|----------------------------------|
| ICD-9-CM | 43400    | CRBL THRMBS WO INFRC            |
| ICD-9-CM | 43401    | CRBL THRMBS W INFRC             |
| ICD-9-CM | 43410    | CRBL EMBLSM WO INFRC            |
| ICD-9-CM | 43411    | CRBL EMBLSM W INFRC             |
| ICD-9-CM | 43490    | CRBL ART OC NOS WO INFRC        |
| ICD-9-CM | 43491    | CRBL ART OCL NOS W INFRC        |
| ICD-9-CM | 43810    | LATE EF-SPCH/LNG DEF NO         |
| ICD-9-CM | 43811    | LATE EFF CV DIS-APHASIA         |
| ICD-9-CM | 43812    | LATE EFF CV DIS-DYSPHIS         |
| ICD-9-CM | 43813    | LATE EFF CV-DYSARTHRIA          |
| ICD-9-CM | 43819    | LATE EF-SPCH/LANG DF NE         |
| ICD-9-CM | 43820    | LATE EF-HEMPLGA SIDE NO         |
| ICD-9-CM | 43821    | LATE EF-HEMPLGA DOM SID         |
| ICD-9-CM | 43822    | LATE EF-HEMPLGA NON-DO          |
| ICD-9-CM | 43831    | LATE EF-MPLGA UP LMB DO          |
| ICD-9-CM | 43841    | LTE EF-MPLGA LOW LMB DO          |
| ICD-9-CM | 43882    | LATE EF CV DIS DYSPHAGI         |
| ICD-9-CM | 43883    | FACIAL WEAKNESS                 |
| ICD-9-CM | 43884    | ATAXIA                          |
| ICD-9-CM | 43885    | VERTIGO                         |
| ICD-9-CM | 43889    | LATE EFFECT CV DIS NEC          |
| ICD-9-CM | 44020    | ATHSCL EXTRM NTV ART NO         |
| ICD-9-CM | 44021    | ATH EXT NTV AT W CLAUDC         |
| ICD-9-CM | 44022    | ATH EXT NTV AT W RST PN         |
| ICD-9-CM | 44023    | ATH EXT NTV ART ULCRTIO         |
| ICD-9-CM | 44024    | ATH EXT NTV ART GNGRENE         |
| ICD-9-CM | 44029    | ATHRSC EXTRM NTV ART OT         |
| ICD-9-CM | 44381    | ANGIOPATHY IN OTHER DIS         |
| ICD-9-CM | 44389    | PERIPH VASCULAR DIS NEC         |
| ICD-9-PCS| 3606     | INS NONDRUG ELUT COR ST         |
| ICD-9-PCS| 3607     | INS DRUG-ELUT CORONRY ST        |
| ICD-9-PCS| 3611     | AORTOCOR BYPAS-1 COR ART        |
| ICD-9-PCS| 3612     | AORTOCOR BYPAS-2 COR ART        |
| ICD-9-PCS| 3613     | AORTOCOR BYPAS-3 COR ART        |
| ICD-9-PCS| 3615     | 1 INT MAM-COR ART BYPASS        |
| ICD-9-PCS| 3616     | 2 INT MAM-COR ART BYPASS        |
| ICD-9-PCS| 3619     | HRT REVAS BYPS ANAS NEC         |
| ICD-9-PCS| _0066    | PTCA OR CORONARY AHER           |
| Brand Name                  | Generic Name                                                   |
|----------------------------|----------------------------------------------------------------|
| PRALUENT PEN               | alirocumab                                                      |
| EZETIMIBE-SIMVASTATIN      | ezetimibe/simvastatin                                          |
| VYTORIN                    | ezetimibe/simvastatin                                          |
| CHOLESTYRAMINE             | cholestyramine (with sugar)                                    |
| CHOLESTYRAMINE LIGHT       | cholestyramine/aspartame                                       |
| COLESTIPOL HCL             | colestipol HCl                                                 |
| PREVALITE                  | cholestyramine/aspartame                                       |
| WELCHOL                    | colesevelam HCl                                                |
| ANTARA                     | fenofibrate,micronized                                         |
| FENOFIBRATE                | fenofibrate                                                    |
| FENOFIBRATE                | fenofibrate nanocrystallized                                   |
| FENOFIBRATE                | fenofibrate,micronized                                         |
| FENOFIBRIC ACID            | fenofibric acid (choline)                                      |
| GEMFIBROZIL                | gemfibrozil                                                     |
| TRICOR                     | fenofibrate nanocrystallized                                   |
| ATORVASTATIN CALCIUM       | atorvastatin calcium                                           |
| CRESTOR                    | rosuvastatin calcium                                           |
| FLUVASTATIN SODIUM         | fluvastatin sodium                                              |
| LIPITOR                    | atorvastatin calcium                                           |
| LIVALO                     | pitavastatin calcium                                           |
| LOVASTATIN                 | lovastatin                                                      |
| PRAVASTATIN SODIUM         | pravastatin sodium                                              |
| ROSUVASTATIN CALCIUM       | rosuvastatin calcium                                           |
| SIMVASTATIN                | simvastatin                                                     |
| NIACIN ER                  | niacin                                                          |
| EZETIMIBE                  | ezetimibe                                                       |
| ZETIA                      | ezetimibe                                                       |
| LOVAZA                     | omega-3 acid ethyl esters                                       |
| OMEGA-3 ACID ETHYL ESTERS  | omega-3 acid ethyl esters                                       |
| VASCEPA                    | icosapent ethyl                                                  |
Table S3. Prescription antihypertensive drugs.

| Brand Name                          | Generic Name                                      |
|-------------------------------------|--------------------------------------------------|
| ACCURETIC                           | quinapril/hydrochlorothiazide                    |
| ACEBUTOLOL HCL                      | acebutolol HCl                                   |
| ACETAZOLAMIDE                       | acetazolamide                                    |
| ADEMPAS                             | riociguat                                        |
| AMILORIDE HCL                       | amiloride HCl                                    |
| AMILORIDE-HYDROCHLOROTHIAZIDE      | amiloride/hydrochlorothiazide                    |
| AMLODIPINE BESYLATE                 | amlodipine besylate                              |
| AMLODIPINE BESYLATE-BENAZEPRIL     | amlodipine besylate/benazepril                  |
| AMLODIPINE-OLMESARTAN               | amlodipine bes/olmesartan med                    |
| AMLODIPINE-VALSARTAN               | amlodipine/valsartan HCTZ                        |
| AMLODIPINE-VALSARTAN-HCTZ          | amlodipine/valsartan/hcthiazid                  |
| ATENOLOL                            | atenolol                                         |
| ATENOLOL-CHLORTHALIDONE            | atenolol/chlorthalidone                          |
| AZOR                                | amlodipine bes/olmesartan med                    |
| BENAZEPRIL HCL                     | benazepril HCl                                   |
| BENAZEPRIL-HYDROCHLOROTHIAZIDE    | benazepril/hydrochlorothiazide                   |
| BENICAR                             | olmesartan medoxomil                             |
| BENICAR HCT                         | olmesartan/hydrochlorothiazide                   |
| BISOPROLOL FUMARATE                | bisoprolol fumarate                              |
| BISOPROLOL-HYDROCHLOROTHIAZIDE    | bisoprolol/hydrochlorothiazide                   |
| BUMETANIDE                          | bumetanide                                       |
| BYSTOLIC                            | nebivolol HCl                                    |
| CANDESARTAN CILEXETIL              | candesartan cilexetil                            |
| CANDESARTAN-HYDROCHLOROTHIAZID    | candesartan/hydrochlorothiazid                   |
| CAPTOPRIL                           | captopril                                        |
| CAPTOPRIL-HYDROCHLOROTHIAZIDE      | captopril/hydrochlorothiazide                    |
| CARDIZEM LA                         | diltiazem HCl                                    |
| CARTIA XT                           | diltiazem HCl                                    |
| CARVEDILOL                          | carvedilol                                       |
| CHLORTHALIDONE                     | chlorthalidone                                   |
| CLONIDINE                           | clonidine                                        |
| CLONIDINE HCL                       | clonidine HCl                                    |
| COREG CR                            | carvedilol phosphate                             |
| COZAAR                              | losartan potassium                               |
| DILTIAZEM 12HR ER                   | diltiazem HCl                                    |
| DILTIAZEM 24HR CD                   | diltiazem HCl                                    |
| DILTIAZEM 24HR ER                   | diltiazem HCl                                    |
| DILTIAZEM ER                        | diltiazem HCl                                    |
| DILTIAZEM HCL                       | diltiazem HCl                                    |
| DILT-XR                             | diltiazem HCl                                    |
| DOXAZOSIN MESYLATE                  | doxazosin mesylate                               |
| DYAZIDE                             | triamterene/hydrochlorothiazid                   |
| EDARBI                              | azilsartan medoxomil                             |
| Brand Name                          | Generic Name                                           |
|------------------------------------|--------------------------------------------------------|
| EDARBYCLOR                         | azilsartan med/chlorthalidone                          |
| ENALAPRIL MALEATE                  | enalapril maleate                                      |
| ENALAPRIL-HYDROCHLOROTHIAZIDE      | enalapril/hydrochlorothiazide                          |
| ENTRESTO                           | sacubitril/valsartan                                   |
| EPLERENONE                         | eplerenone                                             |
| EXFORGE                            | amlodipine besylate/valsartan                          |
| FELODIPINE ER                      | felodipine                                             |
| FOSINOPRIL SODIUM                   | fosinopril sodium                                      |
| FOSINOPRIL-HYDROCHLOROTHIAZIDE     | fosinopril/hydrochlorothiazide                         |
| FUROSEMIDE                         | furosemide                                             |
| HYDRALAZINE HCL                    | hydralazine HCl                                        |
| HYDROCHLOROTHIAZIDE                | hydrochlorothiazide                                    |
| INDAPAMIDE                         | indapamide                                             |
| IRBESARTAN                         | irbesartan                                             |
| IRBESARTAN-HYDROCHLOROTHIAZIDE     | irbesartan/hydrochlorothiazide                         |
| ISRADIPINE                         | isradipine                                             |
| LABETALOL HCL                      | labetalol HCl                                          |
| LASIX                              | furosemide                                             |
| LETAIRIS                           | ambrisentan                                            |
| LISINOPRIL                         | lisinopril                                             |
| LISINOPRIL-HYDROCHLOROTHIAZIDE     | lisinopril/hydrochlorothiazide                         |
| LOSARTAN POTASSIUM                 | losartan potassium                                     |
| LOSARTAN-HYDROCHLOROTHIAZIDE       | losartan/hydrochlorothiazide                           |
| MATZIM LA                          | diltiazem HCl                                          |
| METHAZOLAMIDE                      | methazolamide                                          |
| METHYLDOPA                         | methyldopa                                             |
| METHYLDOPA-HYDROCHLOROTHIAZIDE     | methyldopa/hydrochlorothiazide                         |
| METOLAZONE                         | metolazone                                             |
| METOPROLOL SUCCINATE               | metoprolol succinate                                   |
| METOPROLOL TARTRATE                | metoprolol tartrate                                    |
| METOPROLOL-HYDROCHLOROTHIAZIDE     | metoprolol/hydrochlorothiazide                         |
| MINOXIDIL                          | minoxidil                                              |
| MOEXIPRIL HCL                      | moexipril HCl                                          |
| NADOLOL                            | nadolol                                                |
| NIFEDIPINE                         | nifedipine                                             |
| NIFEDIPINE ER                      | nifedipine                                             |
| NISOLDIPINE                        | nisoldipine                                            |
| OLMESARTAN MEDOXOMIL               | olmesartan medoxomil                                   |
| OLMESARTAN-AMLODIPINE-HCTZ         | olmesartan/amlodipin/hctiazid                         |
| OLMESARTAN-HYDROCHLOROTHIAZIDE     | olmesartan/hydrochlorothiazide                         |
| PERINDOPRIL ERBUMINE               | perindopril erbumine                                   |
| PRAZOSIN HCL                       | prazosin HCl                                           |
| Brand Name                                      | Generic Name                                      |
|------------------------------------------------|---------------------------------------------------|
| PROPRANOLOL HCL                                | propranolol HCl                                   |
| PROPRANOLOL HCL ER                             | propranolol HCl                                   |
| QUINAPRIL HCL                                  | quinapril HCl                                     |
| QUINAPRIL-HYDROCHLOROTHIAZIDE                  | quinapril/hydrochlorothiazide                     |
| RAMIPRIL                                       | ramipril                                          |
| REVATIO                                        | sildenafil citrate                                 |
| SILDENAFIL                                     | sildenafil citrate                                 |
| SPIRONOLACTONE                                 | spironolactone                                    |
| SPIRONOLACTONE-HCTZ                            | spironolact/hydrochlorothiazid                    |
| TARKA                                          | trandolapril/verapamil HCl                        |
| TAZTIA XT                                      | diltiazem HCl                                     |
| TEKTURNA                                       | aliskiren hemifumarate                            |
| TELMISARTAN                                    | telmisartan                                       |
| TELMISARTAN-HYDROCHLOROTHIAZID                 | telmisartan/hydrochlorothiazid                    |
| TENORMIN                                       | atenolol                                          |
| TERAZOSIN HCL                                  | terazosin HCl                                     |
| TIMOLOL MALEATE                                | timolol maleate                                   |
| TOPROL XL                                      | metoprolol succinate                              |
| TORSEMIDE                                      | torsemide                                          |
| TRACLEER                                       | bosentan                                          |
| TRANDOLAPRIL                                   | trandolapril                                      |
| TRANDOLAPRIL-VERAPAMIL ER                      | trandolapril/verapamil HCl                        |
| TRIAMTERENE-HYDROCHLOROTHIAZID                 | triamterene/hydrochlorothiazid                    |
| TRIBENZOR                                      | olmesartan/amlodipin/hctiazid                     |
| VALSARTAN                                      | valsartan                                         |
| VALSARTAN-HYDROCHLOROTHIAZIDE                  | valsartan/hydrochlorothiazide                     |
| VERAPAMIL ER                                   | verapamil HCl                                     |
| VERAPAMIL ER PM                                | verapamil HCl                                     |
| VERAPAMIL HCL                                  | verapamil HCl                                     |
| VERAPAMIL SR                                   | verapamil HCl                                     |