Longitudinal Adherence to Diabetes Quality Indicators and Cardiac Disease: A Nationwide Population-Based Historical Cohort Study of Patients With Pharmacologically Treated Diabetes

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BACKGROUND: Evidence of the cardiovascular benefits of adherence to quality indicators in diabetes care over a period of years is lacking.

METHODS AND RESULTS: We conducted a population-based, historical cohort study of 105,656 people aged 45 to 80 with pharmacologically treated diabetes and who were free of cardiac disease in 2010. Data were retrieved from electronic medical records of the 4 Israeli health maintenance organizations. The association between level of adherence to national quality indicators (2006–2010: adherence assessment) and incidence of cardiac outcome; ischemic heart disease or heart failure (2011–2016: outcome assessment) was estimated using Cox proportional hazards models. During 529,551 person-years of follow-up, 19,246 patients experienced cardiac disease. An inverse dose–response association between the level of adherence and risk of cardiac morbidity was shown for most of the quality indicators. The associations were modified by age, with stronger associations among younger patients (<65 years). Low adherence to low-density lipoprotein cholesterol testing (≤2 years) during the first 5 years was associated with 41% increased risk of cardiac morbidity among younger patients. Patients who had uncontrolled low-density lipoprotein cholesterol in all first 5 years had hazard ratios of 1.60 (95% CI, 1.49–1.72) and 1.23 (95% CI, 1.14–1.32), among patients aged <65 and ≥65 years, respectively, compared with those who achieved target level. Patients who failed to achieve target levels of glycated hemoglobin or blood pressure had an increased risk (hazard ratios, 1.50–1.69) for cardiac outcomes.

CONCLUSIONS: Longitudinal adherence to quality indicators in diabetes care is associated with reduced risk of cardiac morbidity. Implementation of programs that measure and enhance quality of care may improve the health outcomes of people with diabetes.

Key Words: diabetes ■ heart failure ■ ischemic heart disease ■ longitudinal adherence ■ national cohort ■ quality indicators ■ quality of diabetes care
Abdel-Rahman et al Quality of Diabetes Care and Cardiac Disease

Care aims to prevent complications by controlling glucose metabolism, monitoring target organs (eg, ophthalmologist visits, renal function), and treating coexisting risk factors (eg, hypertension and hyperlipidemia). In the past 2 decades, national programs aimed at improvement of health care quality have developed and implemented indicators to evaluate and monitor the quality of diabetes care in the community. Quality indicators mostly include process indicators, which assess the performance of various tests (eg, glycated hemoglobin [HbA1c] testing), and intermediate-outcome indicators, which assess the achievement of certain targets (eg, HbA1c <7% [53 mmol/mol]). Performance of diabetes quality indicators has increased over the past 2 decades across countries. Nevertheless, it is unclear whether this improved performance is associated with improved outcomes. A few studies have suggested that measurement of HbA1c and low density lipoprotein (LDL)-cholesterol are associated with decreased risk of cardiac disease. Yet the evidence on the impact of other process indicators, such as blood pressure (BP) measurement or assessment of renal function, is lacking. Several studies have focused on intermediate-outcome indicators (HbA1c, LDL-cholesterol, and BP) with results varying from major reductions in cardiac morbidity (eg, control of all the 3 indicators reduced the risk by 55%) to weak or nonsignificant associations. Moreover, evidence of the effect of longitudinal adherence to quality indicators over a period of years is lacking. Therefore, we aimed to examine the association between longitudinal adherence to quality indicators and the incidence of cardiac disease among individuals with diabetes in a nationwide, population-based study.

METHODS

The data that support the findings of this study are available from the corresponding author upon reasonable request. We conducted a nationwide historical cohort study of all adults with pharmacologically treated diabetes in 2003 to 2005 in Israel and followed up to 2016. In Israel, 4 health maintenance organizations (HMOs) provide community health care to all permanent residents. Since 2002, these HMOs annually report to the National Program for Quality Indicators in Community Healthcare on a predefined set of diabetes-related indicators.

To be included in the study, patients were required to be aged 45 to 80 years on January 1, 2003, and to be treated with antidiabetic medications (either insulin or oral hypoglycemics) for ≥3 months in at least 1 of the years (2003–2005). Data on quality indicators and demographic and clinical characteristics in the follow-up years were obtained from the electronic medical records of all 4 HMOs.

Quality Indicators

Data on 7 process indicators and 4 intermediate outcomes were collected. Process indicators included annual measurements of HbA1c, LDL-cholesterol, BP, urinary protein, serum creatinine, ophthalmological visit, and administration of influenza vaccine. Attainment of each indicator was defined as performance at least once in a calendar year. Intermediate-outcome indicators assessed whether patients achieved adequate control, using the last measurement in a calendar year. Two indicators were used for glycemic control. The first was an age-specific target (HbA1c ≤7% [53 mmol/mol] for patients aged ≤74 years or HbA1c ≤8% [64 mmol/mol] for patients aged ≥75 years). The second was HbA1c ≤9% (75 mmol/mol) for all ages based on avoidance of uncontrolled diabetes. Adequate control of BP was defined as systolic BP ≤140 mmHg and diastolic blood pressure ≤90 mmHg. For LDL-cholesterol, control was defined as a level ≤100 mg/dL.

Outcome

The primary outcome was incidence of either ischemic heart disease or heart failure. Outcomes were defined according to diagnoses (based on International Classification of Diseases, Ninth Revision [ICD-9] codes 410–414 or 428) and cardiac procedures recorded in CLINICAL PERSPECTIVE

What Is New?

- The quality of diabetes care was inversely associated with the risk of cardiac morbidity: The greater the adherence to diabetes quality indicators over the years, the lower the risk; this holds true for most of the examined quality indicators.
- Most of these associations were stronger among patients aged <65 years compared with older patients.

What Are the Clinical Implications?

- Adherence to diabetes quality indicators may reduce the risk of cardiac morbidity.
- Implementation of programs that measure the quality of diabetes care may improve health outcomes of people with diabetes.

Nonstandard Abbreviations and Acronyms

| Acronym | Definition                     |
|---------|--------------------------------|
| HMO     | health maintenance organization |
| SEP     | socioeconomic position         |

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the electronic medical records, including coronary artery bypass surgery and interventional cardiac catheterization. Sensitivity analyses were conducted using only cardiac procedures as outcomes, as this definition has higher specificity.

**Covariates**

The study covariates included body mass index, calculated using weight in kilograms (median during the study period) divided by height in meters squared (last documented after the age of 18 years), and categorized as normal (<25.0), overweight (25.0–29.9), and obese (≥30.0 kg/m²). Smoking was categorized as never versus ever smoking. Ethnicity (Jewish versus Arab) was inferred on the basis of the location of the primary clinic, as the primary clinics in each HMO are defined by the population they serve. Socioeconomic position (SEP) was defined on the basis of the residential address, using SEP scores (range, 1–10) allocated to small statistical areas by the Israeli Central Bureau of Statistics and updated by the POINTS Location Intelligence Company using current sociodemographic and commercial data. End-stage renal disease was defined according to renal replacement therapy (dialysis or kidney transplant) recorded in the electronic medical records.

Missing data were imputed using multiple imputation by chained equations on the basis of strong predictors with complete data. Missing values of SEP were imputed using age and sex. Height, weight, and ethnicity were imputed using age, sex, and SEP. Smoking was imputed using age, sex, SEP and ethnicity. The percentage of missing values was 4.2% for SEP, 3.1% for ethnicity, 3.0% for body mass index, and 13.8% for smoking.

**Statistical Analysis**

The study period was divided into a baseline period (2006–2010 for adherence assessment) and a follow-up period (2011–2016 for outcome assessment). For each calendar year, quality indicators were dichotomized, scoring 1 if the indicator was attained and 0 otherwise. For intermediate-outcome indicators, nonperformance was coded as nonattainment and received a value of 0. The level of adherence to each quality indicator was defined as the number of years in which the indicator was attained in the baseline period (scoring 0–5) and further categorized (0–2, 3, 4, or 5), because few participants belonged to the groups 0–2. Moreover, to evaluate the combined performance of all process indicators, a composite score was calculated for each year during the baseline period. The score indicated the total number of performed process indicators per year, ranging from 0 (none) to 7 (all). Then, an average composite score over the baseline 5 years was calculated.

We assessed outcomes in patients who were in follow-up and free of cardiac disease in 2010. Patients who did not purchase antidiabetic medications after 2005 (1.4%) were excluded. Follow-up time was calculated from January 1, 2011, to date of cardiac diagnosis or procedure, changing HMO (1.0% of the study population), death, or end of follow-up (December 31, 2016), whichever occurred first. The flowchart of the study population (n=105,656) is presented in Figure 1. Cox proportional hazards models were used to estimate hazard ratios (HRs) and 95% CIs for the associations between adherence to quality indicators and cardiac morbidity.

We examined whether the associations were modified by age, sex, or SEP. A significant interaction was found between age group and most of the quality indicators, even after excluding patients who were treated with insulin in 2006 (10.8%). Therefore, all the analyses were stratified by age (<65 and ≥65 years) and were adjusted for sex, age (continuous), smoking, body mass index, SEP, and HMO. We confirmed the proportional hazards assumption by inspection of log-minus-log plots.

To estimate the potential role of survival bias in the associations between adherence to quality indicators and cardiac disease, especially regarding the stronger associations found among younger patients compared with older ones, sensitivity analyses (Table S1) were conducted examining age modification in the associations between adherence to intermediate-outcome indicators in 2006 and incidence of cardiac disease during 2007 to 2016. Analyses were conducted among (1) patients who were in follow-up and free of cardiac disease in 2010 (n=105,656; ie, the study population) and (2) patients who were in follow-up and free of cardiac disease in 2005 (n=143,252).

For one of the HMOs (8% of the study population), documentation of BP, and vaccination for influenza was missing for 4 and 5 years of the baseline period, respectively; thus, members of this HMO were excluded in the analysis of BP, influenza vaccination, and the process composite score. Sensitivity analyses were conducted while considering missing as nonperformance for the unavailable years.

All statistical analyses were carried out using RStudio, version 3.5.1 (R Core Team, 2018) including “mice,” “mosaic,” and “survival” packages. Two-sided P value <0.05 was considered to be statistically significant.

Ethical approvals were obtained from the institutional review boards of all 4 HMOs: Clalit Health Services (0132-17-com), Maccabi Health Services (0119-17-BBL), Meuhedet Health Services (03-02-10-17) and Leumit Health Services (0237-17-LEU). All 4 institutional review boards waived the requirement for informed consent on the basis of preserving participants’ anonymity.
RESULTS

Table 1 presents the characteristics of the study population. Mean age of participants was 63.3 years (SD, 8.9) in 2006, 58.7% were women, and 84.3% were overweight or obese. During 529,551 person-years of follow-up (median per person, 6 years), 19,246 (18.2%) patients experienced cardiac disease, yielding an incidence rate of 36.3 per 1000 person-years.

Process Indicators

Approximately 70% of the study population had annual testing of HbA1c, LDL-cholesterol, or creatinine, in all baseline years (2006–2010). A slightly lower percentage had recorded measurements for BP (67.2%), and a substantially lower percentage (<40%) were assessed for proteinuria or had an ophthalmological visit or influenza vaccinations. The proportions of adherence were higher among patients aged ≥65 years compared with younger patients (Table 2).

Table 2 presents the HRs (95% CI) for cardiac morbidity by level of adherence to process indicators. Among patients aged <65 years, those who had been tested for LDL-cholesterol only for ≤2 years (low adherence) during the first 5 years, had a higher risk of cardiac morbidity (HR, 1.41 [95% CI, 1.30–1.53]), compared with those who had been tested in all first 5 years (full adherence). Moreover, low adherence to HbA1c or urinary protein test was associated with similarly increased (1.2-fold) risk of cardiac morbidity compared with full adherence in young patients. An inverse dose–response association between the level of adherence in the baseline period and risk of cardiac morbidity was shown for LDL-cholesterol, HbA1c, and urinary protein test. Patients aged <65 years who had
Abdel-Rahman et al. Quality of Diabetes Care and Cardiac Disease

recorded measurements for BP in 4 years, had lower risk of cardiac morbidity (HR, 0.94 [95% CI, 0.89–0.99]) compared with those who were adherent all 5 years. No significant associations were found between BP measurement, creatinine test, or influenza vaccination and risk of cardiac disease among those aged ≥65 years.

Considering only cardiac procedures as the outcome yielded similar results with somewhat attenuated effect sizes (Table S2).

Incorporating all process indicators into a composite score demonstrated that lack of performance of any indicator was associated with increased risk of cardiac morbidity (HR, 1.04 [95% CI, 1.03–1.05]), results were similar for young and old patients (Table 2).

The sensitivity analyses (Table S3) of BP, influenza vaccination, and the process composite score that considered missing (8% of the study population) as nonperformance revealed similar results.

### Intermediate-Outcome Indicators

The percentage of patients who achieved target levels in every year of the baseline period were lower among patients aged <65 years compared with older patients, for LDL-cholesterol ≤100 mg/dL (17.2% versus 23.2%, respectively), for HbA1c ≤7%/≤8% (11.2% versus 29.4%) but not for BP ≤140/90 mm Hg (28.0% versus 24.4%) (Figure 2). Patients who did not achieve the target level of LDL-cholesterol in any of the first 5 years had significantly higher risk of cardiac morbidity, with HRs of 1.60 (95% CI, 1.49–1.72) among patients aged <65 and 1.23 (95% CI, 1.14–1.32) among patients aged ≥65 years. Patients who failed to achieve target levels of HbA1c or BP had similarly increased risks of cardiac morbidity compared with those who were adherent in all 5 years among patients aged <65 years (HbA1c: HR, 1.69 [95% CI, 1.57–1.82]; BP: HR, 1.65 [95% CI, 1.48–1.83]) and among patients aged ≥65 years (HbA1c: HR, 1.50 [95% CI, 1.41–1.61]; BP: HR, 1.57 [95% CI, 1.41–1.74]). Those with HbA1c >9% in all the baseline years had significantly higher risk (HRs, 2.28 and 1.70 among young and older patients, respectively) compared with those with HbA1c ≤9% in all 5 years. An inverse dose–response association between the level of adherence and risk of cardiac morbidity was shown for all intermediate-outcome indicators, and the gradient was more pronounced among patients aged <65 years compared with older patients (Figure 2). The stronger associations between intermediate-outcome indicators and cardiac morbidity among younger patients compared with older ones persisted among patients who were in follow-up and free of cardiac disease in 2005, suggesting that survival bias did not account for our results (Table S1). Similar results were achieved after adjustment for the type of antidiabetic medications (insulin versus oral hypoglycemics in 2006) (not shown) and when considering only cardiac procedures as the outcome (Figure S1). In addition, including all 3

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**Table 1. Baseline Characteristics of the Study Population, According to Age in 2006***

| Variable                        | Total N (%) | Age <65 y N (%) | Age ≥65 y N (%) |
|---------------------------------|-------------|-----------------|-----------------|
| N (%)                           | 105656 (100)| 60855 (57.6)    | 44801 (42.4)    |
| Female sex, %                   | 58.7        | 54.5            | 64.3            |
| Age, y                          | 63.3±8.9    | 56.8±4.6        | 72.2±4.8        |
| Arab, %                         | 13.0        | 16.7            | 7.9             |
| Socioeconomic position          |             |                 |                 |
| 1–2 (low)                       | 4.2         | 5.1             | 3.0             |
| 3–4                             | 26.1        | 26.9            | 25.0            |
| 5–6                             | 42.0        | 41.0            | 43.4            |
| 7–8                             | 21.1        | 20.9            | 21.5            |
| 9–10 (high)                     | 6.5         | 6.0             | 7.1             |
| Ever smokers, %                 | 27.9        | 33.8            | 19.8            |
| BMI, kg/m²                      | 30.3±6.2    | 30.8±6.2        | 29.7±6.0        |
| Overweight, %                   | 38.0        | 36.7            | 39.8            |
| Obese, %                        | 46.3        | 49.8            | 41.4            |
| Insulin treated in 2006, %      | 10.8        | 12.0            | 9.1             |
| Process indicators, % performed in 2006 |             |                 |                 |
| HbA1c                           | 90.3        | 89.1            | 92.0            |
| LDL-cholesterol                 | 89.1        | 87.1            | 91.7            |
| Blood pressure†                 | 82.9        | 80.7            | 86.0            |
| Creatinine                      | 89.9        | 87.9            | 92.6            |
| Urinary protein                 | 70.7        | 69.6            | 72.3            |
| Eye clinic visit                | 61.5        | 57.5            | 66.9            |
| Influenza vaccination†          | 33.9        | 25.8            | 44.8            |
| All process indicators†         | 17.0        | 12.4            | 23.3            |
| Intermediate outcome indicator, %controlled in 2006 |             |                 |                 |
| HbA1c ≤9%                       | 78.6        | 74.2            | 84.7            |
| HbA1c ≤7%/≤8%†                  | 46.6        | 38.1            | 58.2            |
| LDL-cholesterol ≤100 mg/dL      | 46.3        | 43.3            | 50.2            |
| Blood pressure ≤140/90 mm Hg†   | 59.5        | 60.4            | 58.3            |

Overweight, BMI 25.0–29.9; obese, BMI ≥30.0 kg/m²; HbA1c ≤9% (75 mmol/mol); BMI indicates body mass index; HbA1c, glycated hemoglobin; and LDL, low-density lipoprotein.

*Values are expressed as percentage or as means±SD.
†Total=97,333, Nage<65=55,555, and Nage≥65=41,778.
‡HbA1c ≤7% (53 mmol/mol) among patients aged ≤74 y or HbA1c ≤8% (64 mmol/mol) among patients aged ≥75 y.
intermediate-outcome indicators in the same model revealed similar results with modestly attenuated effect sizes compared with the results of the separate models, that is, the association with each intermediate-outcome indicator persisted even after the adjustment for the others (Table S4). Furthermore, adjustment for incidence of end-stage renal disease before 2011 yielded similar results (not shown).

Table 2. Adjusted HR (95% CI) for Cardiac Outcome* (2011–2016) by Level of Adherence to Process Indicators (2006–2010)

| Level of adherence†   | Total N=105656 | Age <65 y N=60855 | Age ≥65 y N=44801 |
|-----------------------|----------------|-------------------|-------------------|
|                       | % HR (95% CI)  | % HR (95% CI)     | % HR (95% CI)     |
| HbA1c‡                |                |                   |                   |
| 0–2 (low)             | 4.0 1.14 (1.06–1.23) | 4.7 1.23 (1.13–1.35) | 2.9 0.95 (0.83–1.08) |
| 3                     | 6.1 1.15 (1.08–1.22) | 6.6 1.13 (1.05–1.22) | 5.4 1.15 (1.05–1.26) |
| 4                     | 17.1 1.11 (1.07–1.15) | 17.6 1.13 (1.08–1.19) | 16.4 1.07 (1.02–1.13) |
| 5 (high)              | 72.8 Reference | 71.0 Reference     | 75.3 Reference     |
| LDL-cholesterol‡      |                |                   |                   |
| 0–2 (low)             | 4.3 1.13 (1.22–1.29) | 5.5 1.41 (1.30–1.53) | 2.7 1.01 (0.88–1.16) |
| 3                     | 6.7 1.18 (1.12–1.25) | 7.7 1.18 (1.10–1.27) | 5.3 1.18 (1.08–1.29) |
| 4                     | 19.0 1.10 (1.06–1.14) | 20.2 1.13 (1.08–1.19) | 17.4 1.05 (1.00–1.11) |
| 5 (high)              | 70.1 Reference | 66.6 Reference     | 74.7 Reference     |
| Blood pressure§       |                |                   |                   |
| 0–2 (low)             | 4.3 1.07 (0.99–1.15) | 4.6 1.08 (0.98–1.19) | 4.0 1.01 (0.90–1.14) |
| 3                     | 7.4 0.99 (0.94–1.05) | 8.5 0.97 (0.90–1.05) | 6.0 1.00 (0.92–1.10) |
| 4                     | 21.0 0.95 (0.91–0.99) | 23.2 0.94 (0.89–0.99) | 18.0 0.96 (0.91–1.01) |
| 5 (high)              | 67.2 Reference | 63.7 Reference     | 72.0 Reference     |
| Creatinine‡           |                |                   |                   |
| 0–2 (low)             | 3.6 1.07 (0.99–1.16) | 4.7 1.14 (1.04–1.25) | 2.1 0.86 (0.74–1.01) |
| 3                     | 6.3 1.02 (0.96–1.08) | 7.6 1.04 (0.97–1.12) | 4.6 0.97 (0.87–1.07) |
| 4                     | 18.9 0.99 (0.96–0.99) | 20.9 1.02 (0.97–1.07) | 16.1 0.95 (0.90–1.01) |
| 5 (high)              | 71.2 Reference | 66.8 Reference     | 77.2 Reference     |
| Urinary protein       |                |                   |                   |
| 0–2 (low)             | 16.2 1.16 (1.11–1.21) | 15.9 1.18 (1.12–1.25) | 16.5 1.10 (1.03–1.17) |
| 3                     | 16.9 1.06 (1.01–1.10) | 17.3 1.07 (1.01–1.13) | 16.4 1.03 (0.97–1.09) |
| 4                     | 29.3 1.00 (0.97–1.04) | 29.5 1.00 (0.95–1.05) | 29.0 1.00 (0.96–1.06) |
| 5 (high)              | 37.6 Reference | 37.2 Reference     | 38.2 Reference     |
| Eye clinic visit‡     |                |                   |                   |
| 0–2 (low)             | 32.0 1.05 (1.01–1.09) | 34.7 1.02 (0.96–1.07) | 28.4 1.06 (1.01–1.12) |
| 3                     | 20.4 0.99 (0.95–1.03) | 22.4 0.96 (0.91–1.02) | 17.8 1.01 (0.95–1.07) |
| 4                     | 22.1 0.99 (0.95–1.03) | 22.3 1.03 (0.97–1.10) | 21.9 0.95 (0.90–1.01) |
| 5 (high)              | 25.4 Reference | 20.6 Reference     | 32.0 Reference     |
| Influenza vaccination§ |                |                   |                   |
| 0–2 (low)             | 52.1 1.04 (1.00–1.08) | 60.0 1.08 (1.02–1.14) | 41.7 1.00 (0.95–1.05) |
| 3                     | 10.7 1.06 (1.00–1.12) | 11.0 1.10 (1.02–1.19) | 10.2 1.03 (0.96–1.11) |
| 4                     | 13.6 1.00 (0.95–1.05) | 12.1 1.03 (0.95–1.11) | 15.7 0.98 (0.92–1.04) |
| 5 (high)              | 23.6 Reference | 16.9 Reference     | 32.4 Reference     |
| Composite score (average over the baseline 5 y)‖ | Continuous | 1.04 (1.03–1.05) | 1.04 (1.03–1.08) | 1.03 (1.02–1.05) |

HbA1c indicates glycated hemoglobin; and LDL, low-density lipoprotein.
*Cardiac outcome: the first occurrence of either ischemic heart disease or heart failure.
†Level of adherence: number of years in which the indicator was attained in 2006–2010.
‡Significant modification by age group. Age in 2006.
§NTotal=97333, Nage<65=55555 and Nage≥65=41778.
‖Composite score: the total number of performed process indicators. Continuous, 0 (none) to 7 (all) (reference).
Adjusted for age, sex, body mass index, socioeconomic position, smoking, and health maintenance organization.
DISCUSSION

In this large population-based historical cohort study, adherence to diabetes quality indicators was associated with cardiac morbidity. Among process indicators considered, the strongest associations were detected for measurements of LDL-cholesterol and HbA1c. Our results suggest that control of HbA1c, LDL-cholesterol, and BP are associated with decreased cardiac morbidity, with an inverse dose–response: the greater the adherence to intermediate-outcome indicators over the years, the lower the risk. The associations were modified by age (except for measurements of urinary protein, influenza vaccination, BP measurement, and BP ≤140/90 mm Hg), with stronger association among those aged <65 years at baseline.

The current study found that not being tested for HbA1c or LDL-cholesterol was associated with a 20% to 40% increased risk for cardiac disease. Although process indicators are widely used in measuring quality of diabetes care, there is limited evidence on the association of process indicators and cardiac morbidity. One previous study of newly diagnosed patients with diabetes (aged ≥67 years) found that HbA1c testing in the year following diabetes diagnosis was associated with a 29% decrease in the probability of cardiac complications.14 Regarding LDL-cholesterol testing, a previous study showed that adults (65–75 years) with diabetes who did not perform lipid tests in 24 months were more likely to die from cardiovascular disease compared with patients who were tested for LDL-cholesterol.15 In the current study, we expanded the findings to younger patients, assessed the association with other process indicators, and estimated the performance of process indicators over a longer period. Interestingly, overall, there was no significant association between BP measurement and risk of cardiac disease. This finding may be related to patients’ ability to measure their BP at home (which is not the case for any other process indicator examined), while our data included only in-office measurements.

Our findings showed that poor glycemic control is strongly and significantly associated with cardiac morbidity. Patients who failed to achieve HbA1c ≤9% or
HbA$_{1c}$ $\leq$ 7.8% in any of the baseline years had about 2- or 1.5-fold increased hazard for cardiac morbidity, respectively. This finding is in accordance with previous studies.19,21-24 That showed that inadequate control of HbA$_{1c}$ was associated with higher risk of cardiac morbidity (eg, HbA$_{1c}$ $>$ 9% was associated with an HR of 1.524). Interestingly, a small study (n=2994; mean age, 76 years) found that the risk of ischemic heart disease was higher in patients with HbA$_{1c}$ of 6.5% to 6.9% compared with HbA$_{1c}$ $\geq$ 7.5%.25 It may well be that this finding is related to strict control of HbA$_{1c}$ among elderly patients, especially those aged $\geq$ 75 years. Notably, large trials showed that intensive glycemic control (≤<6%) did not reduce cardiovascular risk26,27 and was even associated with increased death from cardiovascular causes.27 Of note, recent trials have suggested that new antidiabetic medications (sodium-glucose cotransporter 2 inhibitors and glucagon-like peptide 1 receptor agonists) could reduce the risk of cardiovascular disease independently of HbA$_{1c}$ control.28-30

Our results demonstrated that patients who did not achieve the target level of LDL-cholesterol in any of the baseline years had higher risk of cardiac morbidity with HRs of 1.60 (95% CI, 1.49–1.72) and 1.23 (95% CI, 1.14–1.32), among patients aged <65 and $\geq$ 65 years, respectively. Previous cohort studies19,21,22,31,32 have shown that inadequate control of LDL-cholesterol was associated with increased risk of cardiac morbidity (eg, LDL-cholesterol $\geq$ 130; HR,1.519). Our study adds the modification of association by age, which was especially strong for LDL-cholesterol control.

Our findings indicate that patients who had uncontrolled BP in every year of the baseline period had 60% higher risk for cardiac morbidity compared with those who were controlled in all the baseline years. This is in line with previous studies.19,22,33-35 Notably, a retrospective study showed that patients with systolic blood pressure <125 or $\geq$ 140 mm Hg had an increased risk of cardiovascular diseases.36 Our results showed no significant interaction between age group and BP control, which may support the importance of BP control in older patients. This study focused on the 5-year adherence to intermediate outcomes. Others have recently assessed visit-to-visit variability in HbA$_{1c}$, BP, and LDL-cholesterol and indicated that these variations are associated with increased risk of cardiovascular complications in patients with diabetes.37-41 Further research is therefore needed to examine the potential benefits of incorporating information on variability in quality indicators.

Our results suggest that adherence to quality indicators may yield greater benefits for people aged <65 years compared with older patients in almost all the indicators. These findings are in agreement with the results of 2 large cohort studies that showed stronger associations between intermediate-outcome indicators and cardiac morbidity among younger patients with type 2 diabetes compared with older participants.5,24 In addition, a cohort study with a follow-up period of over 40 years showed that the impact of BP and glucose on incidence of cardiac disease declined with age.42 There are 2 possible explanations for the greater benefits in younger patients. First, controlling diabetes early in the course of the disease may bring beneficial effects that hold for years, that is, the “legacy effect.” Evidence suggests that the “legacy effect” is greater in people with new-onset diabetes.43,44 and age could be a proxy for diabetes duration. Second, prevalence of subclinical cardiac disease increases with age. Indeed, coronary artery calcium score, an established marker of subclinical ischemic heart disease, increases with age, and a score $\geq$ 400, which is indicative of high risk for a cardiac event, is very rare in people aged <65 years.45

Our study has some limitations. First, the study did not include people with diabetes who were managed with lifestyle modifications alone, calling into question the generalizability of our study results. Notably, documentation of laboratory results (HbA$_{1c}$ and glucose) and physician diagnoses during 2003 to 2005 was found to be poor-quality data, while, the quality of data on purchase of antidiabetic medications was high. Furthermore, the latter definition, has a high specificity of diabetes and includes the majority (85% based on Quality Indicators in Community Healthcare data) of people with diabetes. Second, data regarding type of diabetes and duration of disease were missing. Our age restriction minimized the proportion of patients with type 1 diabetes in the cohort. Third, Quality Indicators in Community Healthcare does not cover all aspects of diabetes care (eg, foot care) and available indicators somewhat differ from international guidelines20 (eg, measurement of HbA$_{1c}$ at least once versus twice a year). Fourth, this study cannot distinguish between diabetes care per se and individuals’ characteristics and health behaviors; it could be that healthier patients are more adherent to quality indicators or that patients who are adherent to quality indicators may be more adherent to other health advice (eg, physical activity and diet) that we did not measure. Finally, data regarding use of new antidiabetic medications (glucagon-like peptide 1 receptor agonists and sodium-glucose cotransporter 2 inhibitors) were missing. However, sodium-glucose cotransporter 2 inhibitors became available in 2015 and glucagon-like peptide 1 receptor agonists were not reimbursed as first- or second-line diabetes treatment during 2011 to 2016. Based on data from one of the HMOs, the proportion of people who purchased these drugs during 2011 to 2016 among newly diagnosed diabetic patients was <1% (personal communication).

Our study’s strengths include its comprehensiveness in terms of a national coverage of all Israeli
patients with pharmacologically treated diabetes who were free of cardiac disease in 2010, and the assessment of numerous quality indicators enabling a comparison of the cardiac benefit of adherence to these indicators. In addition, to the best of our knowledge, this is the first study that estimated the associations between the level of adherence over a number of years and incidence of cardiac disease. Finally, the large study population allowed us to explore whether the associations between adherence to quality indicators and cardiac morbidity were modified by age, sex, or SEP.

In conclusion, our results suggest that longitudinal adherence to quality indicators in diabetes care is associated with reduced cardiac morbidity. Quality-of-care programs that increase the performance of quality indicators are probably effective in improving health outcome among people with diabetes, and decision makers could encourage both patients and health providers to strive for high adherence to quality indicators, given their demonstrated association with cardiac morbidity. Future studies are warranted to support our findings.

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All authors contributed to the design of the study. Prof. A. Cohen contributed to the data acquisition from the Clalit Health Services. Dr. E. Elran contributed to the data acquisition from the Maccabi Healthcare Services. Dr. A.G. Cohen contributed to the data acquisition from the Leumit Health Care Services. L. Valinsky contributed to the data acquisition from the Meuhedet Health Services. Dr. N. Abdel-Rahman, Prof. R. Calderon-Margarit, and Prof. O. Manor contributed to the conception of the study, have verified all the data in the study, conducted the data analyses and data interpretation and drafted the manuscript. Prof. A. Ben-Yehuda, Prof. O. Paltiel and, Dr. M. Krieger contributed to data interpretation. All authors critically revised the manuscript for important intellectual content and approved the final version of the manuscript.

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Disclosures
None.

Supplemental Material
Table S1–S5
Figure S1

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Supplemental Material
Table S1. Adjusted hazards ratio (95% CI) for cardiac outcome\(^5\) (2007-2016) by achieving target level in 2006, (A) among patients who were in follow-up and free of cardiac disease in 2005 and (B) among those who were in follow-up and free of cardiac disease in 2010.

| Uncontrolled vs. controlled | A |          |          |          |          |          |
|-----------------------------|---|----------|----------|----------|----------|----------|
|                             |   | Free of cardiac disease in 2005 (N=143,252\(^a\)) |          | Free of cardiac disease in 2010 (N= 105,656\(^b\)) |          |
|                             |   | Age<65 years | Age≥65 years | Age<65 years | Age≥65 years |
|                             |   | N=76,232   | N=67,020  | N=60,855  | N=44,801  |
|                             |   | HR (95% CI) | HR (95% CI) | HR (95% CI) | HR (95% CI) |
| HbA1c (≤7%/≤8%)              | 1.39 | 1.27 | <0.0001 | 1.42 | 1.28 | <0.0001 |
|                             | (1.35-1.43) | (1.22-1.30) |          | (1.36-1.45) | (1.22-1.34) |          |
| LDL-cholesterol (≤ 100 mg/dL) | 1.05 | 1.00 | 0.008 | 1.14 | 1.06 | 0.005 |
|                             | (1.02-1.09) | (0.98-1.03) |          | (1.09-1.19) | (1.02-1.07) |          |
| Blood pressure (≤ 140/90 mmHg) | 1.25 | 1.18 | <0.0001 | 1.23 | 1.21 | 0.6 |
|                             | (1.20-1.30) | (1.14-1.22) |          | (1.17-1.30) | (1.15-1.27) |          |

\(^5\)Cardiac outcome: the first occurrence of either ischemic heart disease or heart failure.

Age in 2006. \(^a\) Analyses of blood pressure N\(_{Total}=132,315\), N\(_{age<65}=69,768\) and N\(_{age≥65}= 62,547\). \(^b\) Analyses of blood pressure N\(_{Total}=97,333\), N\(_{age<65}=55,555\) and N\(_{age≥65}= 41,778\). * P value for interaction between age group and the quality indicator. HbA1c: glycated hemoglobin, HbA1c ≤ 7% among patients aged ≤74 years or HbA1c ≤8% among patients aged ≥75 years.

LDL-cholesterol: low density lipoprotein cholesterol. Adjusted for age, sex, body mass index, Socioeconomic position, smoking and health maintenance organization.
Table S2. Adjusted hazards ratio (95% CI) for cardiac outcome according to procedures\(^5\) (2011-2016) by level of adherence to process indicators (2006-2010).

| Level of adherence* | Total N= 105,656 | Age<65 years N=60,855 | Age≥65 years N=44,801 |
|---------------------|------------------|------------------|------------------|
|                     | %  | HR (95% CI)   | %  | HR (95% CI)   | %  | HR (95% CI)   |
| HbA1c               |     |               |     |               |     |               |
| 0-2 (low)           |    | 1.08 (0.99-1.19) | 4.7 | 1.19 (1.07-1.32) | 2.9 | 0.89 (0.73-1.09) |
| 3                   | 6.1 | 0.99 (0.91-1.06) | 6.6 | 1.04 (0.94-1.14) | 5.4 | 0.94 (0.81-1.08) |
| 4                   | 17.1 | 1.05 (1.00-1.10) | 17.6 | 1.11 (1.04-1.18) | 16.4 | 0.99 (0.91-1.08) |
| 5 (high)            | 72.8 | Reference | 71.0 | Reference | 75.3 | Reference |
| LDL-cholesterol     |     |               |     |               |     |               |
| 0-2                 | 4.3 | 1.23 (1.13-1.33) | 5.5 | 1.33 (1.22-1.46) | 2.7 | 1.00 (0.82-1.22) |
| 3                   | 6.7 | 1.06 (0.98-1.14) | 7.7 | 1.12 (1.03-1.22) | 5.3 | 0.98 (0.85-1.13) |
| 4                   | 19.0 | 1.06 (1.01-1.11) | 20.2 | 1.12 (1.06-1.19) | 17.4 | 0.98 (0.91-1.07) |
| 5                   | 70.1 | Reference | 66.6 | Reference | 74.7 | Reference |
| Blood pressure#     |     |               |     |               |     |               |
| 0-2                 | 4.3 | 0.89 (0.81-0.99) | 4.6 | 0.97 (0.86-1.09) | 4.0 | 0.78 (0.64-0.95) |
| 3                   | 7.4 | 0.95 (0.88-1.02) | 8.5 | 0.97 (0.89-1.06) | 6.0 | 0.93 (0.81-1.07) |
| 4                   | 21.0 | 0.94 (0.89-0.98) | 23.2 | 0.94 (0.89-1.00) | 18.0 | 0.94 (0.87-1.02) |
| 5                   | 67.2 | Reference | 63.7 | Reference | 72.0 | Reference |
| Creatinine          |     |               |     |               |     |               |
| 0-2                 | 3.6 | 1.04 (0.94-1.14) | 4.7 | 1.09 (0.98-1.21) | 2.1 | 0.94 (0.76-1.17) |
| 3                   | 6.3 | 0.98 (0.91-1.06) | 7.6 | 1.02 (0.93-1.11) | 4.6 | 0.93 (0.80-1.08) |
| 4                   | 18.9 | 0.97 (0.93-1.02) | 20.9 | 1.02 (0.96-1.08) | 16.1 | 0.91 (0.83-0.99) |
| 5                   | 71.2 | Reference | 66.8 | Reference | 77.2 | Reference |
| Urinary protein     |     |               |     |               |     |               |
| 0-2                 | 16.2 | 0.98 (0.93-1.04) | 15.9 | 1.11 (1.04-1.19) | 16.5 | 0.83 (0.75-0.92) |
| 3                   | 16.9 | 0.99 (0.94-1.04) | 17.3 | 1.04 (0.97-1.11) | 16.4 | 0.96 (0.88-1.04) |
| 4                   | 29.3 | 0.97 (0.93-1.02) | 29.5 | 1.00 (0.95-1.06) | 29.0 | 0.95 (0.88-1.02) |
| 5                   | 37.6 | Reference | 37.2 | Reference | 38.2 | Reference |
| Eye clinic visit    |     |               |     |               |     |               |
| 0-2                 | 32.0 | 0.91 (0.87-0.96) | 34.7 | 0.96 (0.90-1.03) | 28.4 | 0.90 (0.83-0.97) |
| 3                   | 20.4 | 0.96 (0.90-1.01) | 22.4 | 0.99 (0.92-1.06) | 17.8 | 0.96 (0.88-1.04) |
| 4                   | 22.1 | 0.98 (0.93-1.04) | 22.3 | 1.04 (0.97-1.12) | 21.9 | 0.93 (0.86-1.01) |
| 5                   | 25.4 | Reference | 20.6 | Reference | 32.0 | Reference |
| Influenza vaccination## |     |               |     |               |     |               |
| 0-2                 | 52.1 | 0.96 (0.91-1.01) | 60.0 | 1.05 (0.98-1.12) | 41.7 | 0.88 (0.82-0.94) |
| 3                   | 10.7 | 0.95 (0.88-1.02) | 11.0 | 1.03 (0.93-1.13) | 10.2 | 0.88 (0.78-0.98) |
| 4                   | 13.6 | 0.91 (0.85-0.97) | 12.1 | 0.99 (0.90-1.08) | 15.7 | 0.85 (0.77-0.94) |
| 5                   | 23.6 | Reference | 16.9 | Reference | 32.4 | Reference |

\(^5\)Based on procedures; coronary artery bypass surgery or cardiac catheterization, 11,381 underwent a cardiac procedure during 2011-2016. *Level of adherence: number of years in which the indicator was attained in 2006-2010. Age in 2006. HbA1c: glycated hemoglobin, LDL-cholesterol: low density lipoprotein cholesterol. \(^*\)N\(_{\text{total}}\)=97,333, N\(_{\text{age<65}}\)=55,555 and N\(_{\text{age>65}}\)=41,778. Adjusted for age, sex, body mass index, socioeconomic position, smoking and health maintenance organization.
Table S3. Adjusted hazards ratio (95% CI) for cardiac outcomes\(^5\) (2011-2016) by number of years with achieved indicator (2006-2010). While considering missing of blood pressure and influenza vaccination as non-performance for the unavailable years.

| Level of adherence* | Total N= 105,656 | Age<65 years N=60,855 | Age≥65 years N=44,801 |
|---------------------|------------------|-----------------------|-----------------------|
|                     | HR (95% CI)      | HR (95% CI)           | HR (95% CI)           |
| 0-2 (low)           | 1.08 (1.02-1.14) | 1.03 (0.96-1.11)      | 1.12 (1.03-1.21)      |
| 3                   | 0.99 (0.94-1.05) | 0.97 (0.90-1.05)      | 1.00 (0.92-1.10)      |
| 4                   | 0.95 (0.91-0.99) | 0.94 (0.89-0.99)      | 0.96 (0.91-1.01)      |
| 5 (high)            | Reference        | Reference             | Reference             |

**Process indicator**- Blood pressure

**Process indicator**- Influenza vaccination

**Intermediate outcome indicator**- Blood pressure (≤ 140/90 mmHg)

\(^5\)Cardiac outcome: the first occurrence of either ischemic heart disease or heart failure. *Level of adherence: number of years in which the indicator was attained in 2006-2010. Age in 2006. Adjusted for age, sex, body mass index, socioeconomic position, smoking and health maintenance organization.
Table S4. Adjusted hazards ratio (95% CI) for cardiac outcome\(^5\) (2011-2016) by number of years with achieved target level (2006-2010). Cox proportional hazard model including all the intermediate-outcome indicators.

| Years with achieved target level | Total \(N=97,333\) | Age<65 years \(N=55,555\) | Age≥65 years \(N=41,778\) |
|--------------------------------|--------------------|-----------------------------|-----------------------------|
|                                | HbA1c (≤7%/≤8%)    |                             |                             |
| 0                              | 1.48 (1.41-1.55)   | 1.53 (1.42-1.65)            | 1.42 (1.33-1.52)            |
| 1                              | 1.22 (1.16-1.29)   | 1.23 (1.13-1.33)            | 1.27 (1.18-1.36)            |
| 2                              | 1.09 (1.03-1.16)   | 1.09 (1.00-1.20)            | 1.13 (1.05-1.22)            |
| 3                              | 1.08 (1.02-1.14)   | 1.04 (0.95-1.14)            | 1.14 (1.07-1.22)            |
| 4                              | 1.04 (0.99-1.10)   | 1.05 (0.95-1.15)            | 1.06 (0.99-1.13)            |
| 5                              | Reference          | Reference                   | Reference                   |
|                                |                    |                             |                             |
| Low-density lipoprotein cholesterol (≤100 mg/dL) | | | |
| 0                              | 1.25 (1.19-1.31)   | 1.38 (1.21-1.39)            | 1.08 (1.00-1.17)            |
| 1                              | 1.17 (1.11-1.23)   | 1.30 (1.06-1.22)            | 1.03 (0.96-1.11)            |
| 2                              | 1.07 (1.02-1.13)   | 1.14 (1.03-1.19)            | 1.01 (0.94-1.09)            |
| 3                              | 1.07 (1.02-1.12)   | 1.10 (0.99-1.15)            | 1.04 (0.98-1.11)            |
| 4                              | 1.03 (0.99-1.08)   | 1.07 (1.02-1.03)            | 1.01 (0.95-1.08)            |
| 5                              | Reference          | Reference                   | Reference                   |
|                                |                    |                             |                             |
| Blood pressure (≤140/90 mmHg)   | | | |
| 0                              | 1.45 (1.35-1.57)   | 1.44 (1.29-1.60)            | 1.45 (1.30-1.61)            |
| 1                              | 1.32 (1.24-1.40)   | 1.32 (1.21-1.43)            | 1.29 (1.19-1.40)            |
| 2                              | 1.32 (1.26-1.39)   | 1.32 (1.24-1.42)            | 1.31 (1.22-1.41)            |
| 3                              | 1.19 (1.14-1.24)   | 1.21 (1.13-1.28)            | 1.16 (1.09-1.24)            |
| 4                              | 1.09 (1.05-1.14)   | 1.09 (1.03-1.16)            | 1.09 (1.02-1.16)            |
| 5                              | Reference          | Reference                   | Reference                   |

\(^5\)Cardiac outcome: the first occurrence of either ischemic heart disease or heart failure. Age in 2006. HbA1c: Glycated hemoglobin, HbA1c ≤7% among patients aged ≤74 years or HbA1c ≤8% among patients aged ≥75 years. Adjusted for age, sex, body mass index, socioeconomic position, smoking and health maintenance organization.
| Years with achieved target level | HbA1c (≤9%) | HbA1c (≤7%/≤8%) | Blood pressure | LDL-cholesterol |
|---------------------------------|------------|----------------|---------------|---------------|
|                                 | Male     | Female | Male     | Female | Male    | Female | Male    | Female | Male    | Female |
| 0                               | 2.03     | 2.16   | 1.60     | 1.61  | 1.51   | 1.68  | 1.46    | 1.37   |
|                                 | (1.86-2.22) | (1.99-2.35) | (1.50-1.71) | (1.52-1.72) | (1.36-1.68) | (1.52-1.87) | (1.36-1.57) | (1.28-1.46) |
| 1                               | 1.61     | 1.76   | 1.32     | 1.27  | 1.32   | 1.49  | 1.29    | 1.26   |
|                                 | (1.49-1.75) | (1.62-1.91) | (1.23-1.43) | (1.19-1.37) | (1.21-1.43) | (1.38-1.61) | (1.20-1.39) | (1.18-1.35) |
| 2                               | 1.37     | 1.43   | 1.14     | 1.16  | 1.34   | 1.42  | 1.17    | 1.12   |
|                                 | (1.27-1.48) | (1.33-1.55) | (1.05-1.24) | (1.08-1.25) | (1.25-1.44) | (1.33-1.52) | (1.09-1.26) | (1.05-1.20) |
| 3                               | 1.29     | 1.25   | 1.15     | 1.10  | 1.18   | 1.27  | 1.12    | 1.12   |
|                                 | (1.21-1.38) | (1.17-1.33) | (1.06-1.25) | (1.03-1.19) | (1.11-1.26) | (1.20-1.35) | (1.04-1.20) | (1.05-1.20) |
| 4                               | 1.14     | 1.12   | 1.07     | 1.07  | 1.08   | 1.14  | 1.06    | 1.05   |
|                                 | (1.08-1.20) | (1.06-1.18) | (0.99-1.16) | (1.00-1.15) | (1.01-1.15) | (1.07-1.20) | (0.99-1.14) | (0.99-1.12) |

Table S5. Adjusted hazards ratio (95% CI) for cardiac outcome$^5$ (2011-2016) by number of years with achieved target level (2006-2010), stratified by sex.

$^5$Cardiac outcome: the first occurrence of either ischemic heart disease or heart failure. Age in 2006. HbA1c: Glycated hemoglobin, HbA1c ≤7% among patients aged ≤74 years or HbA1c ≤8% among patients aged ≥75 years, LDL-cholesterol: Low density lipoprotein cholesterol. Adjusted for age, body mass index, socioeconomic position, smoking and health maintenance organization.
**Figure S1:** Adjusted hazards ratio (95% CI) for cardiac outcome according to procedures (2011-2016) by number of years with achieved target level (2006-2010).

| Controlled years | % HbA1C ≤7%/8% | HR (95% CI) | % HbA1C ≤9% | HR (95% CI) |
|------------------|----------------|-------------|-------------|-------------|
| **Age <65, N=60,855** | | | | |
| 0                | 38.2           | 1.80 (1.65-1.97) | 6.4         | 2.21 (2.04-2.40) |
| 1                | 16.7           | 1.37 (1.23-1.51) | 7.1         | 1.68 (1.54-1.82) |
| 2                | 12.6           | 1.21 (1.09-1.35) | 8.8         | 1.47 (1.36-1.60) |
| 3                | 10.9           | 1.14 (1.02-1.28) | 11.8        | 1.28 (1.19-1.38) |
| 4                | 10.4           | 1.09 (0.97-1.23) | 19.7        | 1.12 (1.05-1.20) |
| 5                | 11.2           | Reference       | 40.3        | Reference       |
| **Age ≥65, N=44,801** | | | | |
| 0                | 15.5           | 1.48 (1.34-1.62) | 2.0         | 1.68 (1.40-2.00) |
| 1                | 11.1           | 1.29 (1.17-1.44) | 3.2         | 1.42 (1.23-1.65) |
| 2                | 11.4           | 1.04 (0.94-1.17) | 4.8         | 1.16 (1.01-1.34) |
| 3                | 13.9           | 1.07 (0.96-1.18) | 9.4         | 1.12 (1.01-1.24) |
| 4                | 18.8           | 1.01 (0.92-1.11) | 20.1        | 1.02 (0.94-1.10) |
| 5                | 29.4           | Reference       | 60.5        | Reference       |

| Controlled years | % LDL-cholesterol ≤100 mg/dL | HR (95% CI) | % Blood pressure ≤140/90 mmHg | HR (95% CI) |
|------------------|-------------------------------|-------------|--------------------------------|-------------|
| **Age <65, N=60,855** | | | | |
| 0                | 15.4 | 1.68 (1.55-1.83) | 3.5 | 1.51 (1.33-1.71) |
| 1                | 14.6 | 1.48 (1.36-1.62) | 7.3 | 1.34 (1.21-1.47) |
| 2                | 15.9 | 1.28 (1.17-1.39) | 13.1 | 1.36 (1.25-1.47) |
| 3                | 17.8 | 1.21 (1.11-1.31) | 20.2 | 1.23 (1.15-1.33) |
| 4                | 19.0 | 1.11 (1.02-1.21) | 27.8 | 1.14 (1.06-1.22) |
| 5                | 17.2 | Reference         | 28.0 | Reference         |
| **Age ≥65, N=44,801** | | | | |
| 0                | 11.4 | 1.22 (1.10-1.36) | 4.2 | 1.35 (1.15-1.58) |
| 1                | 11.9 | 1.13 (1.01-1.25) | 8.3 | 1.27 (1.12-1.43) |
| 2                | 14.0 | 1.01 (0.91-1.12) | 14.7 | 1.24 (1.12-1.37) |
| 3                | 17.8 | 1.07 (0.98-1.18) | 21.8 | 1.10 (1.01-1.21) |
| 4                | 21.7 | 1.01 (0.92-1.10) | 26.7 | 0.97 (0.88-1.06) |
| 5                | 23.2 | Reference         | 24.4 | Reference         |

Based on procedures; coronary artery bypass surgery or cardiac catheterization. Lack of measurement considered as uncontrolled, 0 (never controlled during 2006-2010) and 5 (controlled in each year). Circles denote hazard ratio, and horizontal lines represent 95% CI. Age in 2006. N<sub>age<65</sub> = 55,555 and N<sub>age≥65</sub> = 41,778. HbA1c: Glycated hemoglobin, HbA1c ≤7% among patients aged ≤74 years or HbA1c ≤8% among patients aged ≥75 years. LDL-cholesterol: Low density lipoprotein cholesterol. Adjusted for age, sex, body mass index, socioeconomic position, smoking and health maintenance organization.