Preventive Medicine 70 (2015) 19–25

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Association of cardiovascular health screening with mortality, clinical outcomes, and health care cost: A nationwide cohort study

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ARTICLE INFO

Available online 20 November 2014

Keywords:
Cardiovascular diseases
Mortality
Risk factors
Screening

ABSTRACT

Objective. To determine whether a cardiovascular disease (CVD) health screening program is associated with CVD-related health conditions, incidence of cardiovascular events, mortality, healthcare utilization, and costs.

Methods. Cohort study of a 3% random sample of all Korea National Health Insurance members 40 years of age or older and free of CVD or CVD-related health conditions was conducted. A total 443,337 study participants were followed-up from January 1, 2005 through December 31, 2010.

Results. In primary analysis, the hazard ratios for CVD mortality, all-cause mortality, incident composite CVD events, myocardial infarction, cerebral infarction, and cerebral hemorrhage comparing participants who attended a screening exam during 2003–2004 compared to those who did not were 0.58 (95% CI: 0.53–0.63), 0.62 (95% CI: 0.60–0.64), 0.82 (95% CI: 0.78–0.85), 0.84 (95% CI: 0.75–0.93), 0.84 (95% CI: 0.79–0.89), and 0.73 (95% CI: 0.67–0.80), respectively. Screening attenders had higher rates of newly diagnosed hypertension, diabetes mellitus, and dyslipidemia, lower inpatient days of stay and cost, and lower outpatient cost compared to non-attenders.

Conclusions. Participation in CVD health screening was associated with lower rates of CVD, all-cause mortality, and CVD events, higher detection of CVD-related health conditions, and lower healthcare utilization and costs.

Introduction

Cardiovascular disease (CVD) is the most common cause of morbidity and mortality in the world (Celermajer et al., 2012; Minino et al., 2011). Since several CVD risk factors are modifiable, prevention programs routinely screen for hypertension, diabetes, and dyslipidemia (Dalton and Soljak, 2012; Nakanishi et al., 1996; Perk et al., 2012; Thomsen et al., 2006; Will and Loo, 2008) expecting that early detection and treatment of CVD-related health conditions (hypertension, diabetes, dyslipidemia) will decrease the burden of CVD (U.S. Preventive Services Task Force, 2001, 2007, 2008). The effectiveness of screening programs for CVD-related health conditions on health outcomes and healthcare utilization, however, is unclear. Some (Bernacki et al., 1988; Kaczorowski et al., 2011; Nakanishi et al., 1996), but not all (Thomsen et al., 2006; Thomsen et al., 2005), studies have reported higher outpatient treatment rates of CVD-related health conditions and lower hospitalization among participants in screening programs. These studies have been limited by the use of relatively small samples from a limited area (Ren et al., 1994; Thomsen et al., 2006; Thomsen et al., 2005), short follow-up periods (Nakanishi et al., 1996; OXCHECKStudygroup, 1995), or high attrition rates (South-East London Screening Study Group, 2001). Moreover, there is no study that directly links screening to lower CVD events and mortality in the general population (Ebrahim et al., 2011; Krogsboll et al., 2012).

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http://dx.doi.org/10.1016/j.ypmed.2014.11.007
0091-7435/

We hypothesized that screening would be associated with higher detection and outpatient care of CVD-related health conditions and lower incidence of CVD events and mortality. We thus conducted a population-based cohort study to determine whether a nationwide CVD health screening program is associated with CVD incidence, mortality, healthcare utilization, and costs.

Methods

Screening program in Korea

In South Korea, a country with universal healthcare coverage, the Korean National Health Insurance (KNHI) Corporation provides a biennial CVD health screening program to all national health insurance members over 40 years of age free of charge. KNHI is a mandatory social insurance that covers virtually all Koreans except for Medicaid beneficiaries in the lowest income bracket (approximately 3% of the population). The prevention programs aim to detect and treat CVD-related health conditions including hypertension, diabetes, and dyslipidemia early to reduce the burden of CVD and offers subsequent educational counseling or treatment referral for participants with identified health problems. KNHI sends invitation letters to all national health insurance members over 40 years of age. Eligible members can get the screening examination at medical institutions including private clinics and hospitals, and public health centers engaged voluntarily for the national screening program. After the screening, all medical institutions are obligated to report the screening results and send appropriate documented feedback to screening attenders to get reimbursed by the KNHI. People who have abnormal values detected are recommended to seek confirmation of the diagnosis and relevant medical services from nearby medical facilities, and medical services are then provided mainly by private healthcare providers on a fee-for-service basis which is then again reimbursed by the KNHI.

Study population and design

We randomly selected a 3% sample ($n = 621\ 350$) of all KNHI members 40 years of age or older as of December 31, 2002 and made a retrospective cohort. We excluded participants with cancer, diabetes, hypertension, dyslipidemia, or any related CVD including stroke and myocardial infarction ($n = 170\ 490$). As screening was provided biennially, we used two-year windows (e.g., 2003–2004 or 2005–2006) to define participation in screening programs. As a consequence, we further excluded participants who died ($n = 6404$) or were lost to follow-up ($n = 1119$) before January 1, 2005, which is the end of the first two-year period. The final sample size was 443,337 participants. The study was approved by the institutional review board of the Seoul National University Hospital.

Data collection

KNHI collects information necessary for reimbursement of each medical service including age, sex, monthly insurance premium (a proxy for economic status), disability status, disease codes, and costs incurred. Past medical history was based on the diagnoses in KNHI medical service claims data during 2002, coded using the International Classification of Diseases, 10th revision (ICD-10) (Wilchesky et al., 2004). Comorbidities were summarized using the Charlson comorbidity index, a weighted measure of comorbidity. Index is composed of 19 conditions including previous CVD, heart failure, lung diseases, renal diseases, hematologic disorders, liver diseases, neurologic abnormalities, cancers, and AIDS (Klabunde et al., 2007; Klabunde et al., 2000; Nuttall et al., 2006; Sundararajan et al., 2004). In Korea, insurance premium is imposed according to income levels. We used monthly insurance premium as a proxy for their economic status while it might not fully capture the socioeconomic status of a subject, especially if they are retired because it was the only available information representing people's economic status. People with disabilities were identified using the National Disability Registry which contained information about types (15 groups: e.g. auditory, visual, mental, etc.) and severity of disability (Grades 1 to 6: very severe to mild) (Park et al., 2008). As people with any disabilities comprised only 2% of the study sample, we classified the subjects into people without disability and with any disability regardless of type and severity.

We obtained screening participation data from the KNHI screening database. Health questionnaires included information on smoking (non-smoker, ex-smoker, current smoker) and alcohol intake (drinker, non-drinker). Physical exams included measurements of weight, height, and blood pressure. Body mass index (BMI) was calculated as weight in kilograms divided by height in squared meters. Laboratory tests included total cholesterol and fasting blood glucose.

Study outcomes

The primary outcome of the study was CVD mortality. Secondary outcomes were incidence of CVD events, all-cause mortality, detection of CVD-related health conditions, healthcare utilization, and costs. Vital status was ascertained routinely by KNHI by matching with the National Death Registry. Koreans who died abroad were also registered and under-ascertainment of deaths because of out-migration was negligible. CVD deaths were defined as deaths with underlying ICD-10 codes I00–I99 as registered in the National Death Registry data.

Incidence of CVD events, including myocardial infarction (ICD-10 codes I21–I22), ischemic stroke (I63), and hemorrhagic stroke (I60–I62) were defined as inpatient hospitalizations from KNHI claims records. Detection of CVD-related health conditions was defined as the presence of claims for hypertension (I10, I15), diabetes (E10, E118, E119, E13, E149), or hypercholesterolemia (E78) within one year after the screening period. According to instructions from the KNHI, reimbursement for hypertension can be made when blood pressure is $\geq 140/90$ mm Hg at two or more separate visits. According to the American Diabetic Association's guideline, diabetes is defined when fasting blood glucose is ≥ 126 mg/dL at two or more separate visits, HbA1c $\geq 6.5\%$ two or more separate visits, 2-h plasma glucose ≥ 200 mg/dL, or classic symptoms of hyperglycemia with a random plasma glucose ≥ 200 mg/dL are present. Hypercholesterolemia is defined when total cholesterol is >240 mg/dL at two or more separate visits at least 3 months apart. Healthcare utilization and healthcare expenditures incurred included number of inpatient and outpatient days and expenses for diagnosis, monitoring, and treatment of CVD, hypertension, diabetes, dyslipidemia, or related conditions during 2005–2010 from KNHI claims records.

Statistical analysis

We conduct two sets of analyses to test the robustness of the results (Fig. 1). For the primary analysis, we performed multivariate analyses according to attending a health screening visit during 2003–2004 with adjustment for baseline age, sex, economic status, disability, and comorbidity index.

We conducted secondary analysis to control for hidden confounding factors associated with screening attendance. Therefore, for the secondary analysis, we restricted the analysis to 160,607 participants who had attended a health screening visit in 2003–2004. Each of above multivariate analyses were repeated in secondary analysis with adjustment for same covariates considered in the primary analysis plus information on smoking, drinking, body mass index, hypertension, diabetes, and hypercholesterolemia obtained in the 2003–2004 screening visit. Thus, the secondary analysis compares participants who already attended a prior screening visit and who had similar demographic factors, comorbidities, life-style, and CVD-related health conditions. The secondary analysis resulted in 155,620 participants.

In both the primary and the secondary analyses, association between participation in health screening and mortality (CVD and all-cause) and the risk of CVD events (myocardial infarction, cerebral infarction and cerebral hemorrhage, and composite events) was estimated by using Cox proportional-hazards regression models. In the primary analysis, follow-up started on January 1, 2005, while in the secondary analysis, follow-up started on January 1, 2007. Follow-up extended until the development of a CVD endpoint, death, or December 31, 2010, whichever came first. Incidence per 1000 person-years and hazard ratios were reported for each analysis.

In our cohort, the status of screening participation may change over time. For this reason, we also conducted a sensitivity analysis using time-dependent Cox models (Dekker et al., 2008). To investigate the effect of age at screening on the potential difference, we conducted stratified analysis with age <60 and age ≥ 60. Additionally, we repeated the primary and secondary analyses after propensity score matching.

We performed a chi-square test to compare the detection of cardiovascular disease related health conditions within one year after attendance in a cardiovascular health screening program. The differences in healthcare utilization and healthcare expenditures between attenders and non-attenders were analyzed using analysis of covariance (ANCOVA). Statistical analyses were performed in STATA 12.0 (STATA Corp./SE). Statistical significance was defined as two-tailed p-values of <0.05.