Clinical Epidemiology

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ORIGINAL RESEARCH

Patient-reported health as a prognostic factor for adverse events following percutaneous coronary intervention

This article was published in the following Dove Press journal:
Clinical Epidemiology
30 January 2014
Number of times this article has been viewed

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Objective: A relation may exist between self-reported health and adverse events in coronary heart disease. Previous studies have been vulnerable to possible selection bias. In the study reported here, we examined the association between self-rated health and adverse events in terms of cardiac events, cardiac readmissions, and all-cause mortality in a complete cohort of patients treated with percutaneous coronary intervention (PCI).

Study design and setting: A cohort of patients with coronary heart disease treated with PCI was followed up with questionnaires 4 weeks after PCI to measure self-rated health and in registers to identify adverse events. Of 1,752 eligible patients under 67 years, 26 died during the first 4 weeks. A total of 224 patients were excluded from the analysis because they were readmitted with a cardiac diagnosis before answering the first questionnaire. We received complete SF-12 Health Survey component summaries from 984 of the remaining 1,502 patients. We used multiple imputation to establish a complete cohort, including nonrespondents.

Results: During follow-up, 83 patients died, 220 patients experienced a new cardiac event, and 526 patients experienced a hospital readmission related to coronary heart disease. Poor self-rated health was related to cardiac events, cardiac readmission, and all-cause mortality. The associations were stronger for all-cause mortality than for events and readmissions. Physical health was more important than mental health, but both revealed an exposure–response pattern.

Conclusion: Poor self-reported health within 4 weeks of PCI was associated with adverse outcomes during up to 5 years' follow-up.

Keywords: coronary heart disease, patient-reported outcomes, SF-12 adverse events, mortality, multiple imputation

Introduction

Coronary heart disease is a major cause of death and disability. In Denmark, approximately 9,000 patients are treated annually with percutaneous coronary intervention (PCI).[1] Because treatment has improved over the last decades, mortality has declined, resulting in more patients living with heart disease as a chronic condition.[2] However, staying healthy and having no recurrent hospitalizations is crucial following the PCI. A substantial proportion of patients experience readmissions in the years following the initial procedure.[3,4] A systematic review of the current literature on health status as a risk factor of adverse prognosis in coronary heart disease summarized that poor self-reported physical health was associated with adverse events (primarily readmissions) but also mortality.[5] However, most studies were conducted in mixed populations of patients with coronary heart disease, treated with various procedures including not only PCI but also coronary artery bypass grafting.[5] One study focused on PCI-treated

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patients and demonstrated that poor health-related quality of life was related to early (<6 months) but not later events.[6] Recent studies have confirmed the conclusions[7–10] and have shown that mental factors, such as depression and anxiety, are also associated with cardiac events and death.[9,11] Schenkeveld et al examined the eight separate domains of the SF-36 Health Survey, and demonstrated that mental as well as physical domains were related to mortality and that the associations in the physical domains dominated.[7]

Previous studies may lack external validity because they were either post-hoc studies of randomized controlled trials with extensive exclusion criteria or because major proportions of the invited patients did not participate, hence introducing potential selection bias.

The aim of the study reported here was to investigate the relation between mental and physical self-rated health and adverse events shortly after PCI in terms of cardiac events, cardiac readmissions, and all-cause mortality in a complete population-based cohort of working-age patients.

Patients and methods

Patients

The Central Denmark Region is one of five administrative units in Denmark, with 1.25 million inhabitants.[12] All patients referred acutely and electively for PCI are treated at one single unit at Aarhus University Hospital, Skejby in Aarhus. From February 2006 to March 2008, 3,966 patients were treated with PCI. A total of 1,752 patients below 67 years of age were recruited from the in-hospital patient administrative system, and information on addresses and vital status was collected from the Danish Central Person Register (CPR) prior to approaching each patient. Twenty-six patients died within the first 4 weeks, resulting in an eligible cohort of 1,726 patients.

Design

One month after the PCI, the patients were invited to participate in a longitudinal study and mailed the first questionnaire on self-rated health (the SF-12 Health Survey [SF-12]). Patients who agreed to participate in the follow-up study were mailed repetitive questionnaires over a period of at least 3 years. In this particular study, only the first of the repetitive questionnaires was used. The "SF-12" is a generic health survey consisting of 12 questions that correspond to eight subscales. In addition to the eight subscales, the SF-12 also produces two major summary scores, a physical component summary (PCS) and a mental component summary (MCS), each graded from 0 to 100, with higher scores indicating better health.[13] In this article, we present results using the two component scores.

The questionnaires were combined with register data. In Denmark, every resident is provided with a unique personal identification number that enables individual-level linkage between registries. For those who died during follow-up, the exact day of death was obtained from Danish CPR. Data on diagnoses (International Classification of Diseases, tenth edition [ICD-10]) and dates for readmissions before the PCI and during follow-up were obtained from the Danish National Patient Registry.[14] At the time of the final data merge, the register was complete until January 1, 2011.

Sex and age information was obtained from each patient's personal identification number. Clinical baseline data (body mass index [BMI]), smoking status, indication for elective or acute PCI, and left-ventricular ejection fraction (LVEF) were obtained from the West Denmark Heart Registry.[15] Data on public transfer incomes and trade union membership were sourced from the Danish Register for Evaluation of Marginalization.[16]

Methods

We defined four different adverse events: cardiac readmission, cardiac event, cardiac event including death, and all-cause mortality. We identified all admissions for our cohort in the Danish National Patient Registry. The exact timing of answering the first questionnaire for each patient was obtained to determine if an event had occurred before they had answered the questionnaire. Patients with cardiac hospitalizations in the period from PCI to the answering of the first questionnaire (or, for the nonrespondents, during the first 4 weeks) were excluded (n=224), resulting in a final study population of 1,502 patients (Figure 1). The first 7 days preceding PCI were considered related to the initial PCI hospitalization, and thus admissions during the first 7 days were ignored.

Follow-up time was calculated from the date of PCI, with delayed entry at the answering of the first questionnaire. Cardiac admissions were registered by the primary diagnosis in all hospital admissions, and the time to each admission obtained. Cardiac events were defined as ICD-10 codes DI20.0, DI21, DI23, and DI24, while cardiac readmissions also included ICD-10 codes DI20.1, DI20.8, DI20.9, and DI25 along with the cardiac event codes.

For the outcome cardiac event, we used two different scenarios of including information on all-cause mortality: 1) by censoring at the date of death and 2) by including all-cause mortality in the outcome of adverse cardiac event. Only the first occurring event was considered for analysis.

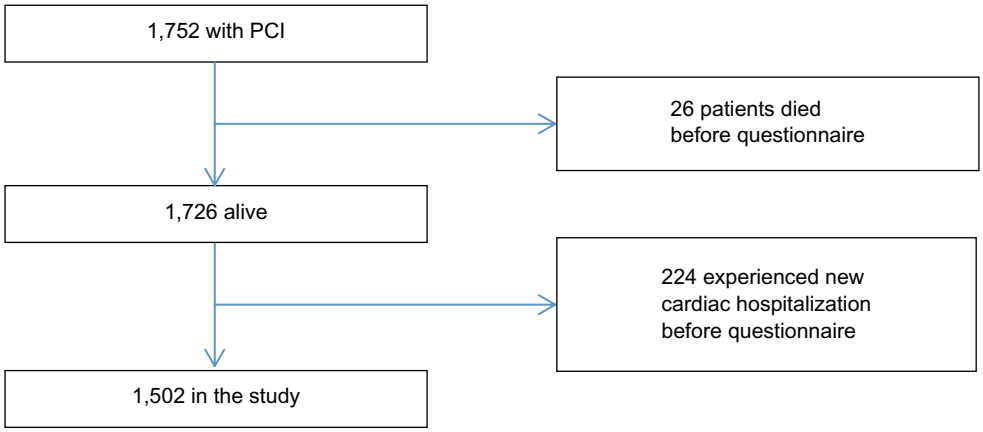

Figure 1 Flowchart of the study population.
Abbreviation: PCI, percutaneous coronary intervention.

For the adverse outcome all-cause mortality, we obtained the exact day of death until follow-up ended in the Danish National Patient Registry on January 1, 2011.

Self-rated health

The two component summaries from the SF-12, the MCS and PCS, were used in their continuous form and categorized according to the 25, 50, and 75 percentiles (rounded to nearest integer), resulting in four categories. MCS was categorized into <42.0, 42.0–49.9, 50.0–56.9, and 57.0+, while PCS was categorized into <38.0, 38.0–45.9, 46.0–52.9, and 53.0+. The MCS and PCS were also dichotomized at the median: 50 in MCS and 46 in PCS.

Covariates

Data on prevalent comorbidity preceding the PCI were recoded to the Charlson Comorbidity Index[14] and categorized into zero, one, or two or more points. Incident comorbidity was derived from admissions following the first questionnaire and coded as an indicator of any readmissions not related to cardiac events. Noncardiac events occurring before the answering of the first questionnaire were identified and used to create an indicator for an early other event. Educational level was derived from self-report or (if missing) from membership of a trade union, recoded according to the International Standard Classification of Education,[17] and dichotomized into low (<10 years' education) versus intermediate/high education. Data on physical activity were dichotomized into low activity (≤4 hours/week) versus high activity (>4 hours/week). Age was dichotomized at 55 years and LVEF was categorized into <30.0, 30.0–44.9, 45.0–59.9, and ≥60. BMI was categorized according to the World Health Organization classifications and dichotomized as normal BMI (<25) versus overweight and obese (≥25). Smoking was grouped into current smokers, previous smokers, and never smokers. Transfer payments at the week preceding the answering of the questionnaire were categorized into the following five groups: 1) working or on work-related benefits, 2) health-related benefits, 3) early retirement, 4) normal retirement, and 5) dead or emigrated.

Statistical analysis

The four different outcome measures are presented separately in Kaplan–Meier plots (Figure 2). We used multiple imputation (MI) to handle missing data in the study.[18,19] For MI of the two component summaries from the SF-12 at the time of the first questionnaire, we used the following of the repetitive questionnaires (answered at 3 months), the transfer payment group at the week preceding the questionnaire, demographics (age and sex), baseline information from the clinical database (LVEF and indication of the PCI), comorbidity in terms of the Charlson Comorbidity Index and noncardiac events (both early and during follow-up), along with the adverse-event outcomes and mortality including times to event. A number of explanatory variables were missing as well (Table 1), and these were imputed along with the SF-12 component summaries before analysis (Supplementary material).

Among nonrespondents, we defined the time of the first questionnaire to 1 month after the PCI. The models for MI including models for other covariates with missing data are shown in detail in the Supplementary material. All analyses were performed in Stata/IC (v 12.1; StataCorp LP, College Station, TX, USA). The imputations (m=100) and the analyses, using Rubin's rule,[20] were performed using the MI suite

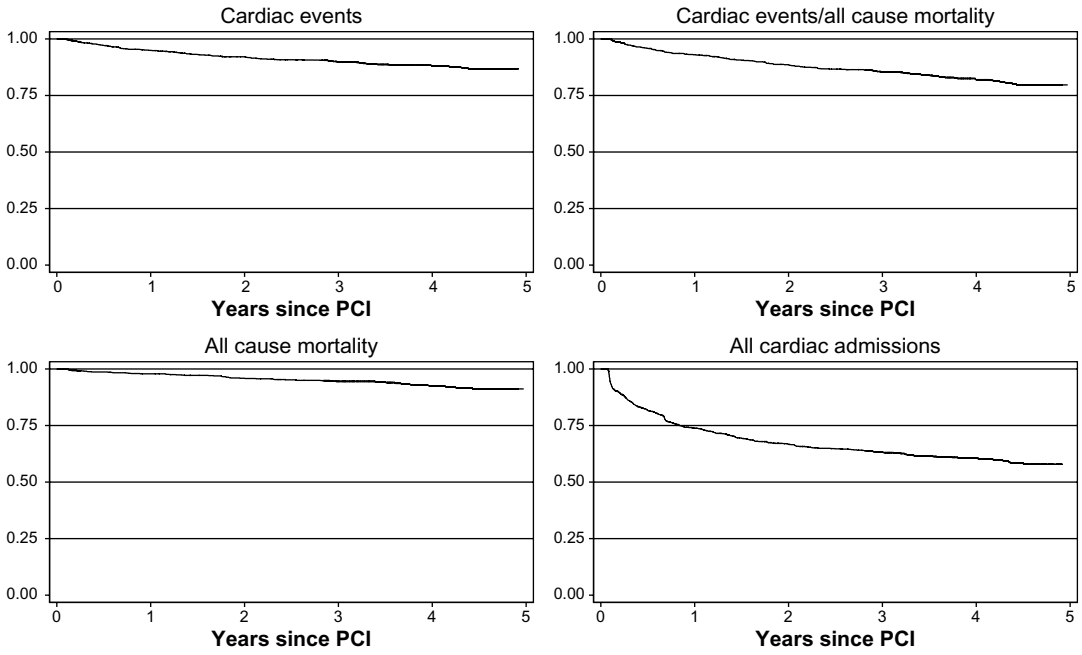

Figure 2 Kaplan–Meier plots.
Abbreviation: PCI, percutaneous coronary intervention.

in Stata. We analyzed the data using the Cox proportional hazards model. To test for proportionality, we examined how log hazard ratios could change over time by allowing them to depend linearly on time. All estimates are given with 95% confidence intervals in parentheses. For the analyses on time to cardiac events, we adjusted for age, sex, comorbidity, indication for PCI, LVEF, educational level, and lifestyle (smoking, physical activity, and BMI). For the analyses on mortality, we adjusted for age, sex, comorbidity, indication for PCI, LVEF, and noncardiac hospital admissions during follow-up.

To challenge the assumption of missing-at-random in the MI, we conducted sensitivity analyses with two different scenarios. First, we subtracted five points from each of the imputed SF-12 scores, equivalent to ½ standard deviation. Second, we subtracted an additional five points in patients who had a Charlson Comorbidity Index score ≥2, assuming that these patients would have rated their health worse than the respondents because of health-related problems due to comorbidity. Half a standard deviation is considered close to the minimal important difference in most quality-of-life measures, and consequently a choice of possible relevant impact on the results.[21]

Results

Baseline characteristics are shown in Table 1. Almost 80% of the patients were men, and 31% were treated acutely. Women were slightly older and less often overweight or obese. Patients treated acutely were younger, had higher LVEFs, were more frequently smokers, and suffered less often from comorbidity. Women experienced more cardiac events and readmissions than men, while mortality was similar. Patients with an acute indication for PCI had a lower mortality than patients with an elective indication, while their frequencies of events and readmissions were comparable.

During follow-up, 83 patients died, 148 experienced a new cardiac event, and 220 had either a new cardiac event or died (in eleven patients, both events occurred on the same day). A total of 526 patients experienced a readmission to hospital related to coronary heart disease, including the cardiac events.

The Kaplan–Meier plots of each of the four different outcomes are presented in Figure 2, which shows that most cardiac readmissions occurred during the first year following PCI, while cardiac events and death occurred with a more evenly distributed frequency during follow-up.

Missing data

Of the total cohort of 1,726 patients, we received questionnaires from 1,323. Among the 1,502 patients in this study, 984 patients completed the SF-12. The nonrespondents differed from the respondents with regard to several aspects; the most important are illustrated in Table 2.

Table 1 Characteristics of 1,502 patients treated with percutaneous coronary intervention, total and stratified by sex and indication

Characteristic	Total, n (%)	Sex, n (%)		Indication of PCI, n (%)	
		Males	Females	Acute	Elective
Total	1,502 (100)	1,181 (100)	321 (100)	470 (100)	1,032 (100)
Cardiac events					
None	1,354 (90)	1,073 (91)	281 (88)	421 (90)	933 (90)
One or more	148 (10)	108 (9)	40 (12)	49 (10)	99 (10)
Cardiac readmissions					
None	976 (65)	790 (67)	186 (58)	304 (65)	672 (65)
One or more	526 (35)	391 (33)	135 (42)	166 (35)	360 (35)
Mortality					
Death during follow-up	83 (6)	65 (6)	18 (6)	22 (5)	61 (6)
Sex					
Males	1,181 (79)	1,181 (100)	–	371 (79)	810 (78)
Females	231 (15)	–	321 (100)	99 (21)	222 (22)
Age, years					
≤44	147 (10)	103 (9)	44 (14)	71 (15)	76 (7)
45–54	415 (28)	340 (29)	75 (23)	138 (29)	277 (27)
55–59	333 (22)	266 (23)	67 (21)	99 (21)	234 (23)
60–67	607 (40)	472 (40)	135 (42)	162 (34)	445 (43)
Indication					
Acute	470 (31)	371 (31)	99 (31)	470 (100)	–
Elective	1,032 (69)	810 (69)	222 (69)	–	1,032 (100)
Comorbidity, Charlson Index					
0	863 (57)	684 (58)	179 (56)	341 (73)	522 (51)
1	351 (23)	281 (24)	70 (22)	70 (15)	281 (27)
2+	288 (19)	216 (18)	72 (22)	59 (13)	229 (22)
LVEF, %					
≤29	35 (2)	26 (2)	6 (2)	8 (2)	27 (3)
30–44	162 (11)	127 (11)	35 (11)	94 (20)	68 (7)
45–59	562 (37)	463 (39)	99 (31)	233 (50)	329 (32)
60+	634 (42)	483 (41)	151 (47)	95 (20)	539 (52)
Missing	109 (7)	79 (7)	30 (9)	40 (9)	69 (7)
Smoking					
Never	290 (19)	227 (19)	63 (20)	70 (15)	220 (21)
Current	670 (45)	512 (43)	158 (49)	290 (62)	380 (37)
Previous	510 (34)	421 (36)	89 (28)	99 (21)	411 (40)
Missing	32 (2)	21 (2)	11 (3)	11 (2)	21 (2)
BMI, kg/m^2					
≤24.9	414 (28)	277 (23)	137 (43)	135 (29)	279 (27)
25.0–29.9	677 (45)	584 (49)	93 (29)	220 (47)	457 (44)
30.0+	374 (25)	291 (25)	83 (26)	97 (21)	277 (27)
Missing	37 (2)	29 (2)	8 (2)	18 (4)	19 (2)
Physical activity, hours/week					
0–2	80 (5)	59 (5)	21 (7)	14 (3)	66 (6)
2–4	351 (23)	259 (22)	92 (29)	110 (23)	241 (23)
>4	410 (27)	347 (29)	63 (20)	129 (27)	281 (27)
>4, heavy	69 (5)	65 (6)	4 (1)	16 (3)	53 (5)
Missing	592 (39)	451 (38)	141 (44)	201 (43)	391 (38)
Educational level, years					
Low (<11)	222 (15)	166 (14)	56 (17)	67 (14)	155 (15)
Intermediate (11–14)	646 (43)	525 (44)	121 (38)	205 (44)	441 (43)
High (15+)	484 (32)	399 (34)	85 (26)	161 (34)	323 (31)
Missing	150 (10)	91 (8)	59 (18)	37 (8)	113 (11)
Transfer payment group					
Working/unemployed	407 (27)	358 (30)	49 (15)	80 (17)	327 (32)
Health-related benefits	534 (36)	422 (36)	112 (35)	233 (50)	301 (29)
Early retirement	382 (25)	268 (23)	114 (36)	106 (23)	276 (27)
Normal retirement	179 (12)	133 (11)	46 (14)	48 (10)	131 (13)

Abbreviations: BMI, body mass index; LVEF, left-ventricular ejection fraction; PCI, percutaneous coronary intervention.

In the time-to-event analysis (Table 3), poor self-rated health was separately associated with cardiac readmissions, cardiac events (with and without all-cause mortality), and all-cause mortality. The estimates for the association with all of the four outcomes were larger for the PCS than for the MCS. Except for the association between the MCS and cardiac events, all measures showed significant exposure–response relationships, again stronger for the PCS than for the MCS. The association between self-rated health and all-cause mortality was stronger than the cardiac readmission and cardiac event outcomes. Log hazard ratios did not change over time, and consequently the assumption of proportional hazards was not rejected.

In 22 patients, the initial PCI was not successful. These patients may have been treated with either a second PCI or coronary artery bypass grafting during the following weeks. This would be registered as a cardiac readmission or event shortly after the initial PCI and could have taken place after the questionnaire date. To ensure that none of these revascularizations would be counted as an event, we excluded these patients in an additional analysis. This exclusion did not change the estimates (data not shown). We adjusted our analyses for a range of covariates that might potentially cause confounding. The adjustment changed the estimates only slightly. In the analysis of mortality, we limited the number of covariates because the numbers of events were few. To adjust for incident comorbidity, we adjusted for hospital admissions not related to coronary heart disease.

Table 2 Characteristics of respondents and nonrespondents in patients treated with percutaneous coronary intervention (PCI)

Characteristic	Respondents,[a] n (%) (n=984)	Nonrespondents, n (%) (n=518)	Chi-square test, *P*
Early other admission[b]	78 (7.9)	81 (15.6)	<0.001
Cardiac event during follow-up	85 (8.6)	63 (12.2)	<0.001
Cardiac admission during follow-up	319 (32.4)	207 (40.0)	<0.001
Other admission during follow-up	332 (33.7)	197 (38.0)	<0.001
Death during follow-up	37 (3.8)	46 (8.9)	<0.001
Comorbidity (Charlson Index >1)	165 (16.8)	123 (23.8)	0.003
LVEF <55%[c]	107 (10.9)	90 (17.4)	0.001

Notes: [a]In this case we defined respondents as patients with complete SF-12, others may have answered the questionnaire, but one or more items were missing; [b]noncardiac hospital admission between PCI and the answering of questionnaire; [c]109 had missing LVEF in the West Denmark Heart Registry.
Abbreviation: LVEF, left-ventricular ejection fraction.

We also analyzed whether sex or indication for PCI could modify the association between patient-reported health and the adverse events, but these stratifications did not change the results (data not shown).

In the analyses of sensitivity, estimates changed only slightly. As a general trend, associations attenuated slightly (data not shown).

Discussion

The results of the present study demonstrate that poor self-reported health shortly after PCI was associated with adverse outcomes during a 5-year follow-up in younger patients. The strongest association was found between self-rated health and death, but associations between self-rated health and cardiac readmissions and cardiac events during follow-up were also present, even with an exposure–response relationship. Physical health revealed the strongest associations, but mental health was also associated with adverse events.

This study was based on a large cohort of PCI patients with information from a variety of registers that included complete information on the outcome measure. The response rate for the patient-reported health measure was relatively high.

However, important differences in the frequency of hospital admissions related to cardiac as well as noncardiac diagnoses, comorbidity, LVEF, and mortality were observed between respondents and nonrespondents. Complete case analysis using data from only the respondents could easily cause selection bias and decrease the number of events during the time-to-event analysis. Because these challenges were unavoidable, we used MI to approach unbiased estimates. To our knowledge, this is the first study to have included a complete population-based cohort with the use of MI and thus be less prone to selection bias. We supplemented with sensitivity analysis to challenge the assumptions behind MI. Inherent to the method, estimates were attenuated, but sensitivity analyses did not change the estimates to any important extent.

LVEF was measured in immediate relation to the PCI procedure, and changes after the PCI were not recorded in the database. Patients who experience an increase in LVEF probably tend to report their health better, but only the baseline LVEF was available in the study. The study was based only on younger PCI patients because the cohort was designed in the setting of occupational medicine with a primary focus on the rehabilitation of the working-age population.

We found that all outcome measures were associated with patient-reported health, but the mechanism behind these associations may be related to disease symptoms, severity, and progression,[22] or related to the patient's health in general.[23] If

Table 3 Association between self-reported mental and physical health (SF-12) with four different adverse events in percutaneous coronary intervention (PCI) patients

	Cardiac event		Cardiac event including all-cause mortality		Cardiac readmission		All-cause mortality	
	Crude HR	Adjusted[a] HR	Crude HR	Adjusted[a] HR	Crude HR	Adjusted[a] HR	Crude HR	Adjusted[b] HR
Mental component summary								
<42.0	1.5 (0.8; 2.6)	1.3 (0.7; 2.4)	1.9 (1.2; 3.0)	1.7 (1.0; 2.8)	1.5 (1.2; 2.1)	1.5 (1.1; 2.0)	3.1 (1.2; 7.8)	2.9 (1.1; 7.5)
42.0–49.9	1.6 (0.9; 2.7)	1.5 (0.8; 2.5)	1.8 (1.1; 2.9)	1.8 (1.1; 2.8)	1.4 (1.0; 1.8)	1.3 (1.0; 1.8)	2.2 (0.9; 5.8)	2.5 (0.9; 6.6)
50.0–56.9	1.3 (0.7; 2.3)	1.3 (0.7; 2.2)	1.4 (0.9; 2.3)	1.4 (0.8; 2.3)	1.2 (0.9; 1.5)	1.1 (0.8; 1.5)	1.7 (0.7; 4.4)	1.7 (0.7; 4.5)
57.0+	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Test for trend, *P*	0.34	0.53	0.029	0.10	0.007	0.022	0.017	0.039
Under 50[c]	1.3 (0.9; 2.0)	1.2 (0.8; 1.9)	1.5 (1.1; 2.2)	1.5 (1.0; 2.1)	1.3 (1.1; 1.7)	1.3 (1.1; 1.6)	2.0 (1.1; 3.7)	2.0 (1.1; 3.8)
1-point decrease[d]	1.01 (0.99; 1.03)	1.01 (0.99; 1.03)	1.02 (1.00; 1.03)	1.02 (1.00; 10.3)	1.02 (1.01; 1.03)	1.01 (1.00; 1.02)	1.03 (1.01; 1.06)	1.03 (1.01; 1.06)
Physical component summary								
<38.0	2.1 (1.3; 3.6)	2.1 (1.2; 3.7)	3.1 (2.0; 4.9)	2.6 (1.6; 4.3)	2.0 (1.6; 2.7)	2.1 (1.6; 2.9)	7.6 (2.7; 21.5)	5.0 (1.7; 14.6)
38.0–45.9	1.5 (0.8; 2.6)	1.4 (0.8; 2.6)	2.0 (1.2; 3.2)	1.7 (1.0; 2.9)	1.3 (1.0; 1.7)	1.3 (1.0; 1.8)	4.4 (1.5; 12.5)	3.4 (1.1; 9.8)
46.0–52.9	1.3 (0.7; 2.3)	1.3 (0.7; 2.3)	1.5 (0.9; 2.6)	1.5 (0.9; 2.5)	1.2 (0.9; 1.6)	1.2 (0.9; 1.6)	2.9 (1.0; 8.5)	2.4 (0.8; 7.0)
53.0+	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Test for trend, *P*	0.004	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	0.005
Under 46[c]	1.6 (1.1; 2.3)	1.5 (1.0; 2.3)	2.0 (1.5; 2.8)	1.8 (1.2; 2.5)	1.5 (1.2; 1.9)	1.5 (1.2; 1.9)	3.2 (1.7; 6.0)	2.5 (1.3; 4.7)
1-point decrease[d]	1.03 (1.01; 1.05)	1.03 (1.01; 1.05)	1.04 (1.02; 1.06)	1.03 (1.02; 1.05)	1.03 (1.02; 1.04)	1.03 (1.02; 1.04)	1.06 (1.03; 1.09)	1.05 (1.02; 1.08)

Notes: Data within parentheses are 95% confidence intervals. [a]Adjusted for age, sex, comorbidity, indication of PCI, LVEF, educational level, and lifestyle (smoking, physical activity, and BMI); [b]adjusted for age, sex, comorbidity, indication of PCI, LVEF, and hospital admissions during follow-up; [c]dichotomous; [d]continuous.

Abbreviations: BMI, body mass index; HR, hazard ratio; LVEF, left-ventricular ejection fraction; ref, reference group.

patient-reported health is related to coronary heart disease, larger risk estimates in relation to cardiac events than to cardiac readmissions would be expected, but this was not the case. If patient-reported health is related to the patient's health in general, we would expect that the results would be confounded by lifestyle and comorbidity, but adjustment for these factors did not change the associations found. However, comorbidity measured with the Charlson Comorbidity Index does not take into account comorbidity treated in general practice or not included in the range of diagnoses in the index, and this comorbidity may have influenced each patient's rating of their health. In addition, the mechanisms behind early and late events may differ, and we were not able to identify differences between early and late events such as those found in the study by Pedersen et al.[6] The results were adjusted for a range of possible confounders, and other unmeasured factors may have influenced the results, such as participation in cardiac rehabilitation, support from relatives and use of medication. Complications following PCI leading to hospital admissions probably occurred during the first weeks and were thus most likely in the group of patients with early cardiac readmission that was excluded.

The broad outcome including all cardiac readmissions may reflect not only severe adverse events but also a high degree of patient self-care. Patients may be especially aware of symptoms related to the heart, lowering the iatrotropic threshold in general. This may lead to readmissions due to suspected angina pectoris and hence to a greater possibility that a diagnosis of restenosis would be made. This behavior may be closely related to patient-reported physical and mental health. When patients are anxious about experiencing a new cardiac event, they may also tend to rate their health worse than less anxious patients, and this may reduce the importance of other well-known risk factors. However, a more narrow definition of cardiac events may exclude episodes of angina, which may lead to repeat vascularization but which, if untreated, may result in a myocardial infarction. We were not able to distinguish between admissions related to the treated vessel and admissions related to other vessels, which would be of great interest if treatment effect were being evaluated. When studying prognosis, we were interested in all new events, as the goal was to prevent these. Events immediately related to the PCI were not included due to the exclusions of patients with events occurring before the answering of the first questionnaire.

We initially aimed to distinguish between cardiac death and noncardiac death. Unfortunately only half of the patients who died had their cause of death registered in the Danish Register of Cause of Death,[24] so the quality of the available data was insufficient for this purpose.

Previous studies have found poor self-rated health associated with adverse outcomes in terms of readmissions and death.[5–10] As recent studies suggest, not only physical but also mental health play an important role in recovery.[6,7,9,11] We also identified mental health associated with the adverse outcomes except in the analysis related to cardiac events without death.

The use of the SF-12 and the timing of the questionnaire are an important issue because we excluded patients with early events. An earlier reporting of self-rated health may solve the problem of events occurring before the questionnaire, but then the rating of health may be related to the acute experience during the hospital admission. The use of the SF-12 at 1 month is related to the wording of the questionnaire, looking backward at the preceding 4 weeks. De Smedt et al found the SF-12v2 Health Survey valid and reliable in a large population of European coronary heart disease patients,[25] and Dempster and Donnelly found the SF-12 to be preferable to the SF-36 in ischemic heart disease patients.[26] Since the SF-12 is shorter than the SF-36, it minimizes the respondent burden but may not distinguish between quality-of-life domains in patients following myocardial infarction.[27] In Mommersteeg et al's review, no differences were identified in the results between studies that used generic health measures and those that used disease-specific health measures.[5]

The cohort in this study covered all incident PCI patients, originating from a well-defined working-age population in Denmark for whom there was complete information on follow-up for the adverse events. The findings have high external validity in relation to countries with similar patient groups referred to PCI.

Conclusion

Physical as well as mental health measured shortly after PCI are associated with subsequent cardiac events, cardiac readmissions, and mortality during up to 5 years' follow-up in younger PCI patients. Even adjustment for several potential confounding factors including age, comorbidity, and LVEF did not attenuate the associations listed in Table 3 substantially, which is an indication of an independent explanatory value of self-reported physical health. The associations between physical health and the adverse outcomes revealed larger risk estimates than those related to mental health, and estimates related to mortality were higher than those

related to cardiac events and readmissions. The use of patient-reported health measures as an important supplement to the data normally available in the clinical setting provides valuable information related to patient prognosis, and may be useful in risk stratification in rehabilitation to target vulnerable patient groups.

Acknowledgments

The Danish Heart Association, The Danish Working Environment Research Fund and Western Denmark Research Forum for Health Research, funded this study. The Danish Data Protection Agency approved the study (reference number 2007-41-0991).

According to Danish law, ethics committee approval and written informed consent from study participants are not required in questionnaire-based and register-based projects. Additional information is available on the webpage of the National Committee on Health Research Ethics in section 14.2 of the Act on Research Ethics Review of Health Research Projects (available from: http://www.cvk.sum.dk/English/actonabiomedicalresearch.aspx).

Disclosure

The authors declare no conflicts of interest in this work.

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Supplementary material

Appendix 1: Multiple imputation, Stata 12.1

```
mi impute chained ///
(regress, include (pcs1 age sex i.smoking bmi i.indication)) lvef ///
(regress, include (mcs1 pcs1 age sex i.smoking i.charlson3)) bmi ///
(mlogit, include (mcs1 pcs1 age sex bmi i.education)) smoking ///
(mlogit, include (mcs1 pcs1 age sex i.dream1 i.smoking i.indication)) education ///
(mlogit, include (mcs1 pcs1 age sexi.smoking bmii.education i.charlson3i.indication)) phys_act ///
///
(regress, include (mcs3 i.dream1 lvef age sex i.charlson3 i..indication early_other_event card_event ///
card_adm mors eventtime admintime morstime)) mcs1 ///
(regress, include (pcs3 i.dream1 lvef age sex i.charlson3 i.indication early_other_event card_event
card_adm /// mors eventtime admistime morstime)) pcs1 ///
///
(regress, include (mcs1 i.dream1 lvef age sex i.charlson3 i. indication early_other_event card_event ///
card_adm mors eventtime admistime morstime)) mcs3 ///
(regress, include (pcs1 i.dream1 lvef age sex i.charlson3 i. indication early_other_event card_event ///
card_adm mors eventtime admistime morstime )) pcs3 ///
///
,add(100) noimputed force rseed(20121213) burnin(60) dots
```