Time Trends in Lifestyle, Risk Factor Control, and Use of Evidence-Based Medications in Patients With Coronary Heart Disease in Europe

Results From 3 EUROASPIRE Surveys, 1999—2013

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Background: The EUROASPIRE (European Action on Secondary and Primary Prevention by Intervention to Reduce Events) cross-sectional surveys describe time trends in lifestyle and risk factor control among coronary patients between 1999 and 2013 in Belgium, Czech Republic, Finland, France, Ireland, the Netherlands, Poland, Slovenia, and the United Kingdom as part of the EuroObservational Research Programme under the auspices of European Society of Cardiology.

Objectives: This study sought to describe time trends in lifestyle, risk factor control, and the use of evidence-based medication in coronary patients across Europe.

Methods: The EUROASPIRE II (1999 to 2000), III (2006 to 2007), and IV (2012 to 13) surveys were conducted in the same geographical areas and selected hospitals in each country. Consecutive patients (≤70 years) after coronary artery bypass graft, percutaneous coronary intervention, or an acute coronary syndrome identified from hospital records were interviewed and examined ≥6 months later with standardized methods.

Results: Of 12,775 identified coronary patients, 8,456 (66.2%) were interviewed. Proportion of current smokers was similar across the 3 surveys. Prevalence of obesity increased by 7%. The prevalence of raised blood pressure (≥140/90 mm Hg or ≥140/80 mm Hg with diabetes) dropped by 8% from EUROASPIRE III to IV, and therapeutic control of blood pressure improved with 55% of patients below target in IV. The prevalence of low-density lipoprotein cholesterol ≥2.5 mmol/l decreased by 44%. In EUROASPIRE IV, 75% were above the target low-density lipoprotein cholesterol <1.8 mmol/l. The prevalence of self-reported diabetes increased by 9%. The use of evidence-based medications increased between the EUROASPIRE II and III surveys, but did not change between the III and IV surveys.

Conclusions: Lifestyle habits have deteriorated over time with increases in obesity, central obesity, and diabetes and stagnating rates of persistent smoking. Although blood pressure and lipid management improved, they are still not optimally controlled and the use of evidence-based medications appears to have stalled apart from the increased use of high-intensity statins. These results underline the importance of offering coronary patients access to modern preventive cardiology programs.

In 2012, the 194 World Health Organization member states adopted a global target to reduce premature mortality from noncommunicable diseases by 25% by 2025 [1]. Cardiovascular disease (CVD) accounts for a majority of noncommunicable disease mortality and is preventable. The World Health Organization adopted targets to achieve this ambition embracing lifestyle, risk factors, and the use of essential medicines and technologies, including preventive and rehabilitative care for those with established CVD. Since 1996, the EUROASPIRE (European Action on Secondary and Primary Prevention by Intervention to Reduce Events) surveys have described the management of coronary patients using comparable methodologies over time [2—8]. The same 9 countries participated in EUROASPIRE II (1999 to 2000) [3], EUROASPIRE III (2007 to 2008) [5], and EUROASPIRE IV (2012 to 2013) [7,8]. These 3 surveys

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included a total of 12,775 consecutive patients with established coronary artery disease of whom 8,456 were interviewed at least 6 months after their initial hospitalization and form the basis for 14-year time trend analyses in lifestyle and therapeutic management compared with targets set by the most recent Joint European Societies Cardiovascular Prevention Guidelines in Clinical Practice [9]. The comparison among the EUROASPIRE I, II, and III surveys showed an increase in obesity, no change in smoking, and poor blood pressure and lipids control despite the substantial increase in blood pressure and lipid-lowering drugs. In EUROASPIRE IV, we looked at the lifestyle and medical risk factors and the use of evidence-based medication as it was important to determine whether the adverse lifestyle and risk factors time trends continued and whether the practice of preventive cardiology has improved by comparison with the previous surveys.

METHODS

Study design

EUROASPIRE II, III, and IV were cross-sectional surveys conducted from 1999 to 2013 in Belgium, the Czech Republic, Finland, France, Ireland, the Netherlands, Poland, Slovenia, and the United Kingdom. The surveys were undertaken in the same geographical areas including at least 1 hospital offering interventional cardiology and cardiac surgery, and 1 or more acute hospitals receiving patients with acute myocardial infarction and unstable angina. A sample of hospitals was taken in such a way that any patient presenting within the geographical area with acute symptoms of coronary disease, or requiring revascularization in the form of balloon angioplasty or coronary artery surgery, had an approximately equal chance of being included in the patient sample. Countries where the surveys were undertaken in different areas were excluded. The number of centers in the 3 surveys was 26, 27, and 32, respectively, from the same geographical areas.

Study population

Consecutive patients, men or women (≥18 years and <70 years at the time of identification), with first or recurrent clinical diagnosis for coronary heart disease were retrospectively identified from diagnostic registers, hospital discharge lists or other sources: coronary artery bypass grafting; percutaneous coronary intervention; acute myocardial infarction; and unstable angina. The starting date for identification was >6 months and ≤3 years prior to the study interview.

Data collection

Information on personal and demographic details, self-reported lifestyle, and medication was obtained at the interviews. Central training of data collectors ensured quality of data collection according to a written protocol, using standardized methodologies for all measurements, equipment calibrated according to the manufacturer's recommendations, and a central laboratory for total and high-density lipoprotein cholesterol and triglycerides (see the Online Appendix). The low-density lipoprotein cholesterol (LDL-C) concentration was calculated using the Friedewald formula in all surveys [10].

Statistical analyses

A total of 2,100 interviewed patients were required from each of the 3 EUROASPIRE surveys to demonstrate differences in prevalence of at least 5% between surveys with 90% power at the 0.05 significance level. Frequency of risk factors, lifestyles, and drug use by survey, country, sex, and age at interview are therefore reported at a European level only using descriptive statistics. Clustering of patients within centers was taken into account using multilevel modeling. A random coefficient model allowed for variation in time trends of risk factor frequencies between countries. The p values for evaluating the null hypothesis of equality in risk factor frequencies between surveys were based on Wald-type tests. Tukey method for correcting p values and confidence intervals was used to account for multiplicity in pairwise comparisons of surveys. Potential confounding due to differences in distributions of age and sex between surveys was adjusted for in all models. All statistical analyses were done with SAS statistical software (version 9.3, SAS Institute, Cary, NC).

TABLE 1. Distribution of study population by survey, sex, and age

	EUROASPIRE II	EUROASPIRE III	EUROASPIRE IV
Sex			
Men	75.6 (2,510/3,320)	78.4 (2,064/2,632)	78.0 (1,961/2,513)
Women	24.4 (810/3,320)	21.6 (568/2,632)	22.0 (552/2,513)
Age at interview			
<60 yrs	48.6 (1,614/3,320)	45.4 (1,195/2,632)	39.0 (980/2,513)
≥60 yrs	51.4 (1,706/3,320)	54.6 (1,437/2,632)	61.0 (1,533/2,513)
Age, yrs	59.4 ± 8.4	60.2 ± 7.8	60.2 ± 7.8

Values are % (n/N) or mean ± SD.
EUROASPIRE, European Action on Secondary and Primary Prevention by Intervention to Reduce Events.

RESULTS

Patient characteristics

A total of 12,775 patients were consecutively identified and 8,456 interviewed (66.2%): 3,320 patients in EUROASPIRE II (1999 to 2000), 2,632 in EUROASPIRE III (2006 to 2007), and 2,513 in EUROASPIRE IV (2012 to 2013) (Table 1). Interview rates were 67.5%, 63.6%, and 51.4%, respectively, slightly lower in female subjects and those ≥60 years. A comparison of those attending for interview with those who did not showed that the interview participation rate was lower in women, in younger patients (except EUROASPIRE II), for those with acute myocardial infarction or unstable angina not revascularized. Median (interquartile range [IQR]) times between the index event and interviews for the 2 surveys were 1.45 (IQR: 1.14, 1.90), 1.22 (IQR: 0.98, 1.63), and 1.39 (IQR: 1.00, 1.92) years. The trends in lifestyle, risk factors, and medications, stratified by the time between recruiting event and interview (less or more than the median of 1.3 years), were very similar for all variables. None of the 2-way interactions between survey and time between recruiting event and interview was significant at p = 0.10 level.

Study outcomes

The prevalence of current smoking, defined as the proportion of all patients smoking at the time of interview, did not differ across the surveys, with the highest rates in youngest (<50 years) patients, in both men and women (Table 2). About one-half of patients were persistent smokers who reported they were smoking in the month prior to their index event and still smoking at the time of interview. Among these smokers a large majority (81.4%, 67.4%, 72.5%; p = 0.19) had attempted to quit following their coronary event. The use of pharmacotherapy for smoking cessation was low and did not change over time.

There was no change in the level of leisure time physical activity. Proportions of patients reaching recommended levels (vigorous physical activity for at least 20 min once or more times a week) were 37.3%, 33.8%, and 41.8%; p = 0.78) across the 3 surveys.

Prevalence of overweight did not differ across the surveys (Table 3). However, prevalence of obesity increased from 31.9% in EUROASPIRE II to 38.5% in EUROASPIRE IV (p = 0.007) with the greatest difference between survey III and IV. The same trend was observed for central obesity.

Prevalence of raised blood pressure dropped from 53.5% to 44.5% (p = 0.01) between EUROASPIRE II and IV. The prevalences of very high blood pressure (systolic ≥160 mm Hg and/or diastolic ≥100 mm Hg) also dropped (21.9%, 16.8%, and 12.8%; p = 0.0006). Therapeutic control of blood pressure in patients using blood pressure–lowering drugs improved with 55% of patients below target in EUROASPIRE IV (Table 4).

The prevalence of raised total cholesterol decreased using either ≥4.5 mmol/l (77.0%, 40.6%, 32.8%; p < 0.0001) or ≥4.0 mmol/l (89.3%, 62.6%, 54.3%; p < 0.0001) as cutpoints, and so did the prevalence of elevated LDL-C ≥2.5 mmol/l (78.0%, 42.9%, 33.5%; p < 0.0001). Using ≥1.8 mmol/l to define elevated LDL-C, the decline over time is also present with 75.3% of patients being above the target <1.8 mmol/l in the most recent survey. Among all patients treated with lipid-lowering drugs, the proportion with LDL-C <1.8 mmol/l increased by 20% between survey II and IV (Table 5). Although the proportion of patients on lipid-lowering drugs was similar between EUROASPIRE III and IV, the use of high-intensity statins (atorvastatin 40 to 80

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TABLE 2. Prevalence of smoking, persistent smoking, and use of pharmacotherapies for smoking cessation by survey, sex, and age

	Smoking*			Persistent Smoking†			Use of Pharmacotherapies‡		
	EA II	EA III	EA IV	EA II	EA III	EA IV	EA II	EA III	EA IV
Sex									
Men	22.0 (552/2,510)	20.7 (426/2,060)	19.1 (374/1,961)	51.1 (498/974)	54.2 (374/690)	53.9 (354/657)	18.6 (73/393)	22.3 (91/408)	24.2 (84/347)
Women	18.1 (146/808)	17.1 (97/568)	15.2 (84/552)	53.8 (134/249)	57.2 (91/159)	48.1 (78/162)	19.8 (21/106)	25.8 (25/97)	20.3 (15/74)
Age at interview									
<60 yrs	29.1 (470/1,614)	28.7 (342/1,193)	27.0 (265/980)	53.6 (419/782)	55.8 (308/552)	54.4 (255/469)	18.9 (62/328)	24.7 (81/328)	27.5 (68/247)
≥60 yrs	13. 4 (228/1,704)	12.6 (181/1,435)	12.6 (193/1,533)	48.3 (213/441)	52.9 (157/297)	50.6 (177/350)	18.7 (32/171)	19.8 (35/177)	17.8 (31/174)
Total	21.0 (698/3,318)	19.9 (523/2,628)	18.2 (458/2,513)	51.7 (632/1,223)	54.8 (465/849)	52.7 (432/819)	18.8 (94/499)	23.0 (116/505)	23.5 (99/421)
Overall significance		p = 0.55			p = 0.67			p = 0.31	
EA III vs.· EA II, %		−1.5 (−5.4 to +2.4), p = 0.43			+2.7 (−4.3 to +9.7), p = 0.43			+5.3 (−4.4 to +15.0), p = 0.26	
EA IV vs.· EA III, %		−0.5 (−4·4 to +3.5), p = 0.80			-2.7 (−10.1 to +4.7), p = 0.46			+1.7 (-8.5 to +11.9), p = 0.72	
EA IV vs.· EA II, %		−2.0 (−5.9 to +1.9), p = 0.30			+0.0 (−7.0 to +7.1), p = 0.99			+7·0 (−2·9 to +17.0), p = 0.15	

Values are % (n/N) or mean difference (95% confidence interval).
EA, EUROASPIRE (European Action on Secondary and Primary Prevention by Intervention to Reduce Events) survey; EA II: NRT, nicotine replacement therapy; EA- III: NRT + bupropion; EA IV: NRT + bupropion + varenicline; ppm, parts per million.
*Self-reported smoking or >10 ppm carbon monoxide in breath.
†Self-reported smoking or >10 ppm carbon monoxide in breath in patients reporting to have been smoking in the month prior to the index event.
‡Pharmacotherapies for smoking cessation among current smokers.

TABLE 3. Prevalence of overweight, obesity, and central obesity by survey, sex, and age

	Overweight*			Obesity†			Central Obesity‡		
	EA II	EA III	EA IV	EA II	EA III	EA IV	EA II	EA III	EA IV
Sex									
Men	79.9 (2,001/2,504)	81.7 (1,677/2,053)	82.6 (1,614/1,953)	29.7 (743/2,504)	31.1 (638/2,053)	36.8 (719/1,953)	44.4 (1,110/2,501)	45.2 (916/2,027)	52.4 (1,011/1,930)
Women	79.7 (641/804)	77.4 (435/562)	79.1 (432/546)	38.9 (313/804)	41.6 (234/562)	44.3 (242/546)	69.7 (561/805)	69.7 (388/557)	74.5 (404/542)
Age at interview									
<60 yrs	80.2 (1,291/1,609)	81.8 (968/1,184)	82.1 (800/974)	33.3 (536/1,609)	36.2 (429/1,184)	39.7 (387/974)	48.5 (779/1,607)	50.3 (588/1,170)	56.0 (540/965)
≥60 yrs	79.5 (1,351/1,699)	79.9 (1,144/1,431)	81.7 (1,246/1,525)	30.6 (520/1,699)	31.0 (443/1,431)	37.6 (574/1,525)	52.5 (892/1,699)	50.6 (716/1,414)	58.1 (875/1,507)
Total	79.9 (2,642/3,308)	80.8 (2,112/2,615)	81.9 (2,046/2,499)	31.9 (1,056/3,308)	33.3 (872/2,615)	38.5 (961/2,499)	50.5 (1,671/3,306)	50.5 (1,304/2,584)	57.2 (1,415/2,472)
Overall significance	p = 0.25			p = 0.007			p= 0.04		
EA III vs. · EA II,%	+0.8 (−2.5 to +4.2), p = 0.62			+1.4 (−3.1 to +5.9), p = 0.51			+0.6% (−5.3 to +6.6), p=0·82		
EA IV vs. · EA III, %	+1.9 (−1.5 to +5.3), p = 0.26			+6.1 (+1.5 to +10.8), p = 0.01			+6.5 (+0.4 to +12.6), p = 0.04		
EA IV vs. · EA II, %	+2.7 (−0.7 to +6.0), p = 0.11			+7.5 (+3.0 to +12.1), p = 0.003			+7.1 (+1.2 to +13.1), p = 0.02		

Values are % (n/N) or mean difference (95% confidence interval).
Abbreviations as in Table 2.
*Body mass index ≥25 kg/m^2.
†Body mass index ≥30 kg/m^2.
‡Waist circumference ≥88 cm for women or ≥102 cm for men

mg or rosuvastatin 20 to 40 mg or simvastatin 80 mg) increased from 23.0% to 45.1%.

The prevalence of self-reported diabetes increased (18.5%, 23.8% to 27.2%; p = 0.004).

The use of evidence-based medications in the surveys is described in Tables 6 and 7. The frequency of evidence-based medications use increased between EUROASPIRE II and III but did not change between EUROASPIRE III and IV surveys.

DISCUSSION

The EUROASPIRE cross-sectional surveys undertaken on 3 occasions over a period of 14 years describe time trends in risk factor control and use of evidence-based medications among coronary patients. Lifestyle factors are deteriorating with increasing prevalences of obesity and central obesity and corresponding increases in the prevalence of diabetes mellitus. The control of blood pressure and LDL-C has improved over this period, but most patients have still not achieved the guideline targets. The proportion of patients on evidence-based medications did not change between 2006 and 2013 although the use of high-intensity statins almost doubled. By comparison with standards set in the European guidelines on CVD prevention, there is still considerable potential to reduce the risk of recurrent disease and improve survival.

There is a wealth of scientific evidence from meta-analyses of randomized controlled trials and observational studies that secondary prevention and cardiac rehabilitation are effective in reducing both cardiovascular and total mortality [11−14]. The comprehensive, multifactorial approach to reduce total cardiovascular risk is strongly underlined in European and U.S. guidelines on cardiovascular prevention [9,15]. Recent studies such as EUROACTION and GOSPEL (Global Secondary Prevention Strategies to Limit Even Recurrence After Myocardial Infarction) provide scientific evidence that structured, multidisciplinary programs achieve healthier lifestyles and more effective risk factor control than usual care does [16,17]. In contrast, the reality of cardiac rehabilitation provision, as described in EUROASPIRE III, varies widely. Only 45% of the patients were advised to attend and only 36% of those eligible participated [18]. These patients had by comparison with nonparticipants, improved lifestyle and risk factor management after 1 year. A health economics analysis from EUROASPIRE III showed that preventive care for coronary patients is cost effective for different health economies across Europe [19]. Yet, despite the evidence for cost effectiveness, the results of the European Cardiac Rehabilitation Inventory Survey show that provision of high-quality services is limited because of lack of funding, no professional guidelines, or weak health service infrastructure [20].

The EUROASPIRE surveys show that the prevalence of persistent smokers did not change over the years but, importantly, that most smokers attempted to quit after their coronary event, indicating a genuine wish to do so.

TABLE 4. Prevalence of the use of blood pressure—lowering drugs and hypertension control by survey, sex, and age

	Blood Pressure—Lowering Drugs*			Hypertension Control†		
	EA II	EA III	EA IV	EA II	EA III	EA IV
Sex						
Men	84.9 (2,129/2,509)	95.4 (1,955/2,050)	96.1 (1,876/1,952)	47.8 (1,017/2,127)	48.2 (940/1,952)	55.5 (1,039/1,872)
Women	90.0 (728/809)	96.6 (545/564)	93.6 (513/548)	39.4 (285/724)	46.3 (251/542)	54.5 (279/512)
Age at interview						
<60 yrs	85.4 (1,378/1,614)	94.3 (1,117/1,185)	94.3 (918/973)	53.5 (736/1,375)	53.8 (599/1,114)	62.7 (574/916)
≥60 yrs	86.8 (1,479/1,704)	96.8 (1,383/1,429)	96.3 (1,471/1,527)	38.3 (566/1,476)	42.9 (592/1,380)	50.7 (744/1,468)
Total	86.1 (2,857/3,318)	95.6 (2,500/2,614)	95.6 (2,389/2,500)	45.7 (1,302/2,851)	47.8 (1,191/2,494)	55.3 (1,318/2,384)
Overall significance		$p < 0.0001$			$p = 0.01$	
EA III vs.· EA II, %		+9.5 (+6.0 to +13.0), $p < 0.0001$			+1.7 (−5.7 to +9.0), $p = 0.63$	
EA IV vs.· EA III, %		−0.1 (−3.5 to +3.3), $p = 0.93$			+9.3 (+1.9 to +16.7), $p = 0.02$	
EA IV vs.· EA II, %		+9.4 (+5.8 to +12.9), $p < 0.0001$			+11.0 (+3.6 to +18.4), $p = 0.006$	

Values are % (n/N) or mean difference (95% confidence interval).
Abbreviations as in Table 2.
*Blood pressure lowering drugs: angiotensin-converting enzyme inhibitors; angiotensin-receptor blockers; beta-blockers; calcium-channel blockers; diuretics; α-blockers.
†Hypertension control in patients on blood pressure—lowering medication, systolic blood pressure <140 mm Hg and/or diastolic blood pressure <90 mm Hg for patients without diabetes (<140/80 mm Hg for patients with diabetes).

This intention is more likely to be successful if supported by a smoking cessation specialist using evidence-based pharmacotherapy [21,22]. Yet only a minority of the participants in EUROASPIRE received support and drugs for smoking cessation.

Obesity and central obesity have increased together with diabetes mellitus across the 3 surveys with an increased risk of recurrent macrovascular disease, microvascular disease, and further reduction in life expectancy. In a mortality follow-up of the EUROASPIRE I cohort of 5,216 coronary patients, the independent modifiable risk factors associated with an increased risk of dying were smoking, cholesterol, and poor glucose control [23]. The potential to reduce that risk in diabetes is considerable by combining lifestyle and risk factors control and evidence-based medications [24,25].

In contrast, blood pressure and lipid control are improving, although many patients are still not achieving the targets set in the current 2012 Joint European Societies Guidelines on CVD Prevention despite high prescription rates for evidence-based medications. These rates are comparable to trial populations such as the REACH

TABLE 5. Prevalence of the use of lipid-lowering drugs and dyslipidemia control by survey, sex, and age

	Lipid-Lowering Drugs*			Dyslipidemia Control†		
	EA II	EA III	EA IV	EA II	EA III	EA IV
Sex						
Men	61.8 (1,551/2,509)	90.5 (1,856/2,050)	90.5 (1,767/1,952)	6.4 (87/1,362)	22.3 (328/1,468)	26.6 (400/1,502)
Women	56.2 (455/809)	88.7 (500/564)	87.2 (478/548)	5.0 (20/402)	15.6 (64/410)	21.7 (90/414)
Age at interview						
<60 yrs	63.8 (1,029/1,614)	90.5 (1,072/1,185)	90.1 (877/973)	5.5 (50/906)	20.0 (169/847)	21.9 (161/735)
≥60 yrs	57.3 (977/1,704)	89.9 (1,284/1,429)	89.6 (1,368/1,527)	6.6 (57/858)	21.6 (223/1,031)	27.9 (329/1,181)
Total	60.5 (2,006/3,318)	90.1 (2,356/2,614)	89.8 (2,245/2,500)	6.1 (107/1,764)	20.9 (392/1,878)	25.6 (490/1,916)
Overall significance		$p < 0.0001$			$p < 0.0001$	
EA III vs.· EA II, %		+29.9 (+24.0 to +35.8), $p < 0.0001$			+15.0 (+10.0 to +20.1), $p < 0.0001$	
EA IV vs.· EA III, %		−0.9 (−6.6 to +4.9), $p = 0.76$			+4.8 (−0.6 to +10.1), $p = 0.08$	
EA IV vs.· EA II, %		+29.1 (+23.1 to +35.0), $p < 0·0001$			+19.8 (+14.8 to +24.8), $p < 0.0001$	

Values are % (n/N) or mean difference (95% confidence interval).
Abbreviations as in Table 2.
*Lipid-lowering drugs: statins; fibrates; bile acid sequestrants (anion exchange resins); nicotinic acid and its derivates; cholesterol absorbtion inhibitors
†Dyslipidemia control in patients on lipid-lowering medication, low-density lipoprotein <1.8 mmol/l.

TABLE 6. Evidence-based medication by survey, sex, and age

	Antiplatelet Therapy			Beta-Blockers			ACE-Inhibitors and ARB		
	EA II	EA III	EA IV	EA II	EA III	EA IV	EA II	EA III	EA IV
Sex									
Men	86.8 (2,178/2,509)	94.8 (1,943/2,050)	95.4 (1,863/1,952)	63.3 (1,589/2,509)	82.0 (1,680/2,050)	81.6 (1,592/1,952)	40.9 (1,026/2,509)	71.0 (1,456/2,050)	73.5 (1,435/1,952)
Women	80.3 (650/809)	92.2 (520/564)	92.3 (506/548)	60.3 (488/809)	80.5 (454/564)	77.0 (422/548)	46.5 (376/809)	73.2 (412/563)	60.6 (332/548)
Age at interview									
<60 yrs	86.0 (1,388/1,614)	95.1 (1,127/1,185)	96.2 (936/973)	64.7 (1,044/1,614)	81.4 (965/1,185)	79.5 (774/973)	38.5 (622/1,614)	68.6 (813/1,185)	71.1 (692/973)
≥60 yrs	84.5 (1,440/1,704)	93.5 (1,336/1,429)	93.8 (1,433/1,527)	60.6 (1,033/1,704)	81.8 (1,169/1,429)	81.2 (1,240/1,527)	45.8 (780/1,704)	73.9 (1,055/1,428)	70.4 (1,075/1,527)
Total	85.2 (2,828/3,318)	94.2 (2,463/2,614)	94.8 (2,369/2,500)	62.6 (2,077/3,318)	81.6 (2,134/2,614)	80.6 (2,014/2,500)	42.3 (1,402/3,318)	71.5 (1,868/2,613)	70.7 (1,767/2,500)
Overall significance		$p < 0.0001$			$p < 0.0001$			$p < 0.0001$	
EA III vs.· EA II, %		+9.2 (+6.5 to +11.9), $p < 0.0001$			+18.7 (+11.8 to +25.7), $p < 0.0001$			+29.1 (+22.8 to +35.4), $p < 0.0001$	
EA IV vs.· EA III, %		+0.5 (−2.0 to +2.9), $p = 0.70$			1.5 (−8.5 to +5.5), $p = 0.65$			−0.2 (−6.6 to +6.2), $p = 0.94$	
EA IV vs.· EA II, %		+9.6 (+7.0 to +12.3), $p < 0.0001$			+17.2 (+10.3 to +24.2), $p < 0.0001$			+28.9 (+22.5 to +35.3), $p < 0.0001$	

Values are % (n/N) or mean difference (95% confidence interval).
ACE, angiotensin-converting enzymes; ARB, angiotensin-receptor blockers; other abbreviations as in Table 2.

TABLE 7. Evidence-based medication by survey, sex, and age

	Calcium-Channel Blockers			Diuretics			Statins		
	EA II	EA III	EA IV	EA II	EA III	EA IV	EA II	EA III	EA IV
Sex									
Men	18.8 (472/2,509)	18.9 (387/2,049)	19.3 (377/1,952)	12.5 (313/2,509)	20.3 (416/2,050)	22.4 (437/1,952)	56.7 (1,422/2,509)	89.1 (1,827/2,050)	89.4 (1,746/1,952)
Women	31.3 (253/809)	24.1 (136/564)	23.0 (126/548)	24.6 (199/809)	31.2 (176/564)	24.1 (132/548)	50.7 (410/809)	87.4 (493/564)	85.8 (470/548)
Age at interview									
<60 yrs	20.4 (329/1,614)	17.8 (211/1,185)	16.2 (158/973)	10.8 (175/1,614)	16.6 (197/1,185)	16.8 (163/973)	58.5 (944/1,614)	89.0 (1,055/1,185)	89.2 (868/973)
≥60 yrs	23.2 (396/1,704)	21.8 (312/1,428)	226 (345/1,527)	19.8 (337/1,704)	27.6 (395/1,429)	26.6 (406/1,527)	52.1 (888/1,704)	88.5 (1,265/1,429)	88.3 (1,348/1,527)
Total	21.9 (725/3,318)	20.0 (523/2,613)	20.1 (503/2,500)	15.4 (512/3,318)	22.6 (592/2,614)	22.8 (569/2,500)	55.2 (1,832/3,318)	88.8 (2,320/2,614)	88.6 (2,216/2,500)
Overall significance		$p = 0.76$			$p = 0.002$			$p < 0.0001$	
EA III vs.· EA II, %		−1.4 (−5.8 to +3.1), $p = 0.52$			+5.9 (+2.3 to +9.5), $p = 0.003$			+9.5 (+6.0 to +13.0), $p < 0.0001$	
EA IV vs.· EA III, %		+0.0 (−4.5 to +4.6), $p = 0.99$			+0.9 (−2.9 to +4.7), $p = 0.63$			−0.1 (−3.5 to +3.3), $p = 0.93$	
EA IV vs· EA II, %		−1.3 (−5.8 to +3.1), $p = 0.54$			+6.8 (+3.1 to +10.5), $p = 0.001$			+9.4 (+5.8 to +12.9), $p < 0.0001$	

Values are % (n/N) or mean difference (95% confidence interval).
Abbreviations as in Table 2.

registry and the STABILITY study, but considerably higher than the PURE (Prospective Urban Rural Epidemiology) study including the high-income countries [26—28]. Yet, there appears to be a ceiling to prescribing with no increase in the proportions of patients on any of the blood pressure— or lipid-lowering drugs between EUROASPIRE III and IV. However, the progress was being made, as there was a 2-fold increase in the proportion of patients on high-intensity statins between EUROASPIRE III and IV. The next steps for reducing the risk of recurrent disease could be by optimizing the dose of evidence-based medications and improving patient adherence.

By comparison with earlier multinational studies in Europe and the United States, the prevalence and control of cardiovascular risk factors is comparable [29—32]. The 9-year trends (1998 to 2006) in achievement of risk factor goals in patients with CVD showed that adherence to guidelines was suboptimal and lower in Europe than in the United States [29]. In patients with CVD and diabetes type 2, NHANES (National Health and Nutrition Examination Survey) reported significant improvements in blood pressure, LDL-C, and triglycerides, but only modest improvements in lifestyle factors.

Strengths and limitations

The EUROASPIRE surveys are conducted in selected geographic regions which are not nationally representative and the centers selected within each region include at least 1 center offering interventional cardiology and cardiac surgery but not necessarily all centers do so. Therefore, there is a conservative bias because the reality of secondary prevention practice outside these specialist centers will be poorer than described by EUROASPIRE. The interview rates across all 3 surveys combined was 66%, but this is not a true participation rate as it was not possible to identify all those who had moved away or died and these patients are still included in the denominator. The falling interview rate may reflect falling participation in medical research generally [33], for which there are many reasons, including increasing restrictions by ethics committees on how patients are recruited and patients being less willing to volunteer. However, this introduces a similar conservative bias because nonresponders are more likely to be persistent smokers with unhealthier diets and an even more sedentary lifestyle. This is supported by a comparison of patient characteristics at hospital discharge in those who attended for interview with those who did not in the countries that participated in EUROASPIRE IV. The interview participation rate was significantly lower in women, in smokers, and in those with abnormal glucose metabolism [7]. Therefore, the evidence-practice gap between guideline recommendations for lifestyle, medical risk factors, and evidence-based medications and patient management described by these EUROASPIRE surveys is likely to be much wider.

CONCLUSIONS

The adverse lifestyle factors trends described by the EUROASPIRE surveys in patients surviving the development of coronary disease, characterized by high levels of persistent smoking and inexorable increases in obesity, central obesity, and diabetes, will mitigate to some extent the gains made in improving blood pressure and lipid control. The progress with lipids management and the use of evidence-based medications that has been made since 1999 has slowed down in the past 5 years. A modern preventive cardiology program could bring together all elements of "cardiac rehabilitation" and "secondary prevention" to deliver a comprehensive service addressing all aspects of lifestyle, medical risk factor control, and prescription of, and adherence with, evidence-based medications. All cardiovascular patients should be guaranteed access to modern preventive cardiology programs in every country in order to gain, beyond those initial lifesaving treatments, longer, healthier, and productive lives.

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APPENDIX

Data collection and data management

Data collection. Measurements were made with the following instruments:

1. Height and weight in light indoor clothes without shoes (SECA scales [Hamburg, Germany] and measuring stick, model number 707 in EUROASPIRE II and SECA scales 701 and measuring stick model 220 in EUROASPIRE III and IV). Overweight was defined as a body mass index $\geq$25 kg/m^2 and obesity as a body mass index $\geq$30 kg/m^2.
2. Waist circumference was measured using a metal tape applied horizontally at the point midway in the mid-axillary line between the lowest rim of the rib cage and the tip of the hip bone (superior iliac crest) with the patient standing. Central obesity was defined as a waist circumference of $\geq$88 cm for women and $\geq$102 cm for men.
3. Blood pressure was measured twice on the right upper arm in a sitting position using an automatic digital sphygmomanometers (Omron 711 [Kyoto, Japan] in EUROASPIRE II, Omron M5-I in EUROASPIRE III, and Omron M6 in EUROASPIRE IV) and the mean was used for all analyses. Raised blood pressure was defined as systolic blood pressure (SBP) $\geq$140 mm Hg and/or diastolic blood pressure (DBP) $\geq$90 mm Hg in patients with no diabetes, and SBP $\geq$140 mm Hg and/or DBP $\geq$80 mm Hg in patients with diabetes.
4. Breath carbon monoxide was measured in parts per million using a smokerlyzer (Bedfont Scientific [Kent, UK] model EC50 in EUROASPIRE II, model Micro4 in EUROASPIRE III, and model Micro+ in EUROASPIRE IV). Smoking at the time of interview was defined as self-reported smoking and/or a breath carbon monoxide exceeding 10 parts per million. Persistent smoking was defined as smoking at interview among patients who reported smoking in the month prior to the index event.
5. Venous (fasting) blood was drawn for serum total and high-density lipoprotein cholesterol and triglycerides. Elevated LDL-C concentration was defined as $\geq$1.8 mmol/l (70 mg/dl).
6. Leisure time physical activity was assessed with the following question: Which of the following 4 best describes your level of activity outside work? 1) No physical activity weekly; 2) only light physical activity in most weeks; 3) vigorous physical activity at least 20 min once or twice a week; 4) vigorous physical activity for at least 20 min 3 or more times a week.

The monitors in EUROASPIRE II (Omron 711) and III (Omron M5-I) were compared in 100 patients and blood pressures from survey II had to be adjusted: corrected SBP = observed SBP − 0.95 mm Hg; corrected DBP = observed DBP + 1.42 mm Hg. According to the manufacturer, no conversion formula is required for measurements obtained by Omron M6 and Omron M5-I.

In EUROASPIRE II, serum from venous blood was used for lipid measurements. The samples were stored at ≤ -20°C. Total cholesterol measurements were performed at the Department of Medicine, University of Manchester, UK on a Cobas Mira S auto-analyzer (Roche Diagnostics, Basel, Switzerland) using Unimate 7 (Roche) cholesterol reagent. The coefficient of variation for total cholesterol was 1.2% during the study. In EUROASPIRE III and IV serum from venous samples were stored at −70°C. Total cholesterol was measured at the central laboratory at the Disease Risk Unit, National Institute for Health and Welfare, Helsinki, Finland, on a clinical chemistry analyzer (Architect c8000, Abbott Laboratories, Abbott Park, Illinois, USA, using enzymatic method for measuring). Because the methods used for cholesterol measurement in EUROASPIRE II and III differed, the performance of the methods was compared by remeasuring a total of 183 samples from EUROASPIRE II in the EUROASPIRE III central laboratory and no significant difference was found (mean difference: 0.011 mmol/l, 95% confidence interval: −0.050 to +0.029) between these laboratories. Data from the external quality assessment programs demonstrated no systematic error in the cholesterol method during the study.

Self-reported diabetes at interview was based on a history of diabetes diagnosed by a physician.

Written, informed consent was obtained from each patient and the study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki as reflected in a priori approval by the institution's ethics research committee.

Data management. In EUROASPIRE II, all data were stored electronically using a unique identification number for country, center, and individual. Data from each country was transferred to the Coordinating Centre (Cardiovascular Medicine, National Heart and Lung Institute, Imperial College London, UK). In EUROASPIRE III and IV, data were also collected electronically and submitted via the Internet to the data management center at European Heart House, Sophia Antipolis, France. Data were checked for completeness, internal consistency, and accuracy. All data were stored under the provisions of the National Data Protection Regulations.

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