ORIGINAL ARTICLE

Smoking ban in public places and myocardial infarction hospitalizations in a European country with high cardiovascular risk: insights from the Polish nationwide AMI-PL database

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KEY WORDS

acute myocardial infarction, cardiovascular hospitalizations, prevention, risk factor, tobacco smoking

ABSTRACT

INTRODUCTION Previous studies demonstrated a possible positive effect of a smoking ban in public places on cardiovascular outcomes. However, little is known about the influence of such regulations in Poland, a country with a high cardiovascular risk.

OBJECTIVES We aimed to evaluate the association of hospitalization rates for acute myocardial infarction (AMI) in Poland before and after the introduction of the smoking ban in public places in November 2010.

PATIENTS AND METHODS The Nationwide Acute Myocardial Infarction Database (AMI-PL) was searched for the cases of AMI that occurred between 2009 and 2014. The analysis considered sex, age (20–64 years vs 65 years or older), and the place of residence (rural vs urban area). There were no specific exclusion criteria.

RESULTS The overall average number of AMI hospitalizations in the years 2009–2010, 2011–2012, and 2013–2014 was 79 323, 80 783, and 77 356, respectively. Age-standardized rates of AMI hospitalizations in both sexes and age groups decreased only slightly in the first 2 years and were more visible in the years following the implementation of the smoking ban. In men, the decrease was observed in both age groups and almost in the whole country. In younger women, the decrease was not observed in towns with more than 100 000 inhabitants. In large towns (over 500 000 inhabitants), mostly a non-significant decrease occurred.

CONCLUSIONS After the introduction of the smoking ban, a marked decrease in age-standardized AMI hospitalizations was observed in long-term follow-up both in men and women as well as both in younger and older patients, but with differences regarding the place of residence.

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INTRODUCTION Cardiovascular diseases (CVDs) are the main cause of mortality in Poland.[1] Like other Central and Eastern European countries, Poland has a high CVD risk, with high premature CVD mortality.[2] Recent data from the European Commission indicated that in 2016 the standardized CVD death rate per 100 000 men aged 25 to 64 years in Poland reached 125, while in Germany, it was 60; in the United Kingdom, 58; and in the Netherlands, only 32.[3] Although Poland has experienced a steady decrease in CVD mortality rates since the 1990s, it is still considerably higher than the European Union average.[4] Recent research has suggested that a decrease of

50% in CVD mortality observed between 1991 and 2005 was mainly attributable to favorable lifestyle changes (eg, a decrease in cholesterol levels, improved control of hypertension, and decreased prevalence of active smoking).[5] Comparable studies conducted in other countries showed similar patterns, with a reduction of approximately 50% in CVD mortality.[6] Taken together, modifying these CVD risk factors via public policy interventions may have a beneficial effect at the population level.

The link between active smoking and the development of CVD is well established. For example, a recently published meta-analysis of 141 cohort studies has shown that smoking even 1 cigarette a day is associated with an increase of nearly 50% and 57% in CVD risk in men and women, respectively.[7] Moreover, there is growing evidence that second-hand smoke is also one of the major contributors to CVD mortality, and it was estimated to increase the risk of acute myocardial infarction (AMI) by 30%.[8] The evidence on the impact of a reduction in tobacco smoke exposure on AMI admissions is diverse.[9-11] The results differ with respect to the timing of the effects (rapid or only long-term) and range from nonsignificant reductions[10] to reductions by even up to 47% in AMI admissions.[11]

In Poland, a public smoking ban was introduced on November 15, 2010, leading to a marked decrease in tobacco smoke exposure in public places.[12] The largest, more than twofold, reduction was recorded in gastronomic and entertainment facilities (from 36% in 2009 to 14% in 2011).[12] Therefore, it would be reasonable to expect a decrease in hospital admissions due to AMI and in CVD mortality rates in the years following the ban. Because of a high CVD burden in the Eastern European countries and lack of such data, there is a high need for this analysis. Thus, we aimed to assess the hospitalization rates for AMI in Poland before and after the introduction of the smoking ban in public places with regard to age, sex, and the place of residence.

PATIENTS AND METHODS We searched the Polish nationwide Acute Myocardial Infarction Database (AMI-PL) for all cases of AMI that occurred between 2009 and 2014. The design of AMI-PL has been described earlier.[13] In brief, the database contains the record of all AMI cases provided by the National Health Fund, the sole public and compulsory health insurer in Poland. The National Health Fund has signed contracts with private and public healthcare providers and it is the only payer of medical procedures. Therefore, it provides unified electronic nationwide data on medical procedures and disease incidence. The AMI cases are selected based on a primary diagnosis coded in the *International Classification of Diseases, Tenth Revision* as I21 or I22, irrespective of any AMI occurrence in the past.

We analyzed the number of hospital admissions for AMI in subsequent years in the general population before (2009–2010) and after (2011–2014) the introduction of the smoking ban in Poland in November 2010. Given that the ban was introduced as late as in November, the year 2010 was classified together with 2009 as the one preceding the smoking ban. The years 2011–2014 were divided into 2-year periods: short-term (2011–2012) and long-term (2013–2014) to search for temporal trends. We also analyzed prespecified subgroups, based on patients' sex, age (20–64 years vs 65 years or older), and place of residence (rural [<2000 people] vs urban [2000 to <100 000 people, 100 000–200 000 people, 200 000–500 000 people, and >500 000 people]). There were no specific exclusion criteria. The study did not require approval by an ethics committee.

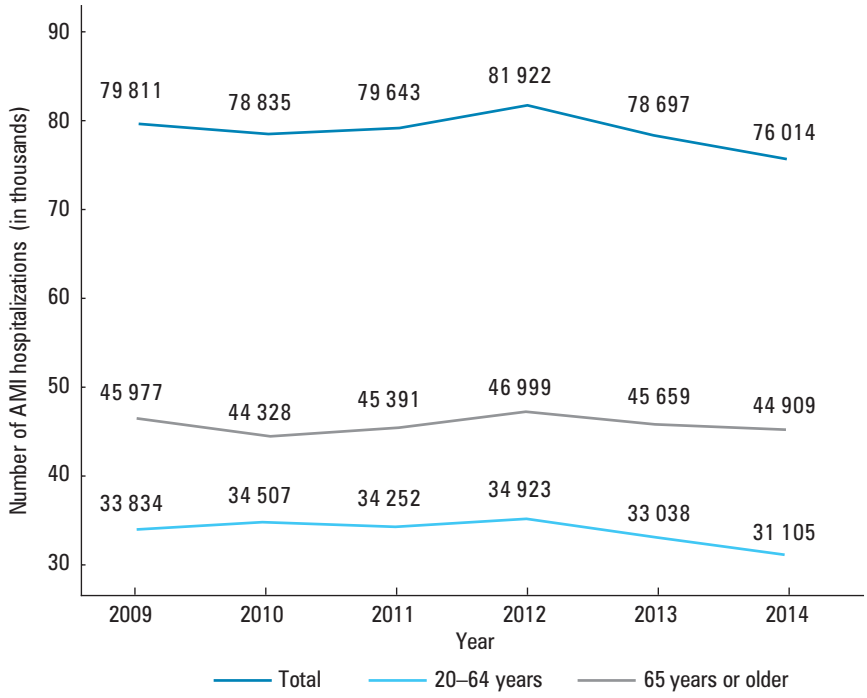
Statistical analysis To eliminate a possible effect of changes in the age structure of the Polish population over time, we calculated age-standardized hospitalization rates applying to the age structure of the total Polish population in the period 2013 to 2014 as standard (the same for men and women to enable a comparison of sex differences in rates and trends). The age-standardized hospitalization rates were presented together with confidence intervals (CIs). We considered the differences between the rates to be significant when 95% CIs were not overlapping. Crude numbers of hospitalizations due to AMI in the subsequent years were also provided for the whole population and for both age groups.

RESULTS In the years 2009 to 2010, before the introduction of the smoking ban, the average number of hospitalizations due to AMI in Poland in patients aged 20 years or older was 79 323. In the subsequent years, the hospitalization rate initially increased (2011–2012), but then decreased (2013–2014), with the average number of hospitalizations of 80 783 and 77 356, respectively. Between the years before the introduction of the smoking ban (2009–2010) and in the subsequent period (2013–2014), a reduction in the number of AMI hospitalizations was observed in both age groups (FIGURE 1).

In both sexes and age groups, the age-standardized hospitalization rates for AMI decreased only slightly after the 2-year period of 2011 to 2012 but were more visible in the subsequent years (2013–2014) (FIGURE 2A and 2B).

Following the introduction of the smoking ban, hospitalizations for AMI decreased markedly in both sexes and age groups in the long-term follow-up. Data are presented in TABLES 1 and 2. In men, the hospitalization rates decreased in both age groups and in all rural and urban areas (regardless of the number of inhabitants). Moreover, a reduction in the number of AMI hospitalizations in men was already seen in most places of residence in the initial period (2011–2012). However, in younger women (20–64 years), the decline in the rates of AMI hospitalizations was not observed in towns with more than 200 000 inhabitants during the whole study. Among older

FIGURE 1 Unadjusted number of hospitalizations for acute myocardial infarction (AMI) in Polish residents aged 20 to 64 years and 65 years or older before and after the introduction of the smoking ban (on November 10, 2010)



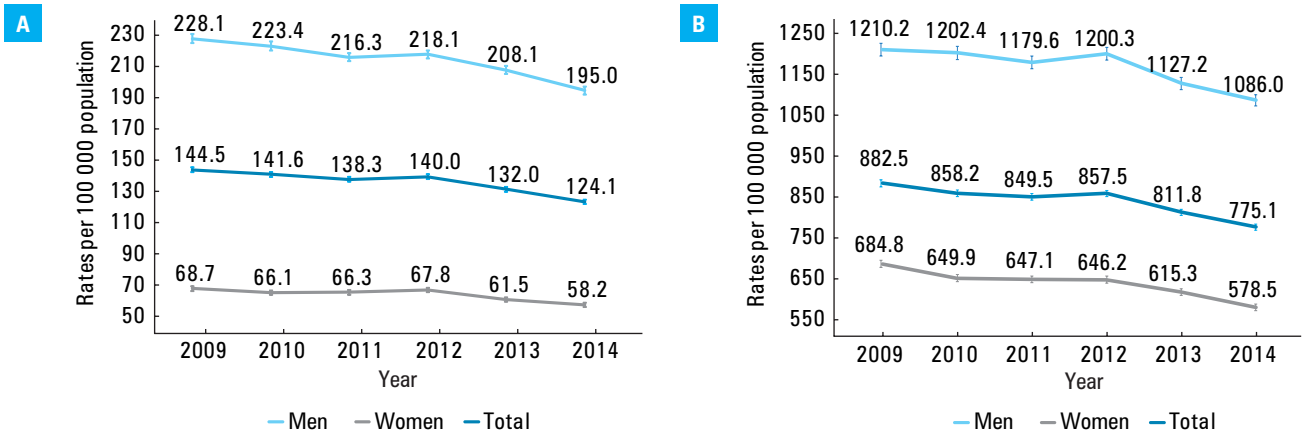


FIGURE 2 Age-standardized hospitalization rates (with marked CIs) for acute myocardial infarction of men and women aged 20 to 64 years (**A**) and 65 years or older (**B**) by the number of residents in Poland, before and after the introduction of the smoking ban (on November 10, 2010)

people (>65 years), only in women in large towns (over 500 000 inhabitants), no significant decline in the rates of hospitalizations for AMI during the whole study was observed.

DISCUSSION Our study showed that after the introduction of the smoking ban, the rate of AMI hospitalizations decreased both in men and women as well as both in younger and older patients. The decline occurred mainly in the long-term follow-up. However, it was not significant in female inhabitants of urban areas (>100 000 inhabitants).

In contrast to short-term studies, we found no decline in the total number of AMI hospitalizations in the 2-year period (2009–2010) following the ban implementation, as compared with the subsequent period of the years 2011 and 2012. A decrease in the rates of AMI hospitalizations was observed only in the long-term follow-up, when comparing the years 2009–2010 to 2013–2014. Comparable European studies, conducted in England, Spain, and Italy, showed an early significant decrease in the number of hospital admissions due to AMI following public smoking prohibition.[14,15] This suggests an immediate impact of a smoking ban on the rate of AMI hospitalizations. In Spain, a reduction in mortality due to AMI was observed already in the first year after the introduction of smoke-free regulations.[9]

The discrepancies between studies may partly result from different study designs and ways in which smoking bans were applied in different settings. In regions where the bans were implemented as a stepwise process, the findings were inconsistent, showing a low reduction,[16] no significant reduction,[10] or a significant decrease in admission rates in the year after a complete smoking ban, as in the Danish population.[17] In the United States, the New York state introduced partial smoking restrictions in 1989, followed by a comprehensive

TABLE 1 Age-standardized hospitalization rates for acute myocardial infarction in a population aged 20 to 64 years before (2009–2010) and after (2011–2012 and 2013–2014) smoking ban introduction

Place of residence (number of residents; rates per 100 000)	Age-standardized hospitalization rates for AMI					
	Men			Women		
	2009–2010	2011–2012	2013–2014	2009–2010	2011–2012	2013–2014
Rural area	189.5 (186.5–192.5)	183.3 (180.5–186.2)	171.0 (168.3–173.6)	60.2 (58.5–61.9)	60.2 (58.6–61.9)	53.1 (51.5–54.6)
Towns (2000 to <100 000)	250.8 (247.2–254.4)	240.8 (237.4–244.2)	223.6 (220.3–226.9)	75.2 (73.4–77.1)	72.8 (71.1–74.6)	65.0 (63.4–66.7)
Towns (100 000–200 000)	250.9 (243.7–258.2)	241.8 (234.8–248.7)	223.3 (216.7–229.9)	69.5 (65.9–73.1)	73.3 (69.7–76.8)	63.9 (60.6–67.2)
Towns (200 000–500 000)	239.4 (232.8–245.9)	227.1 (220.8–233.4)	211.1 (204.9–217.3)	65.2 (62.0–68.3)	64.9 (61.8–68.0)	60.2 (57.1–63.2)
Towns (>500 000)	235.4 (229.6–241.3)	231.3 (225.5–237.1)	216.4 (219.7–222.0)	63.0 (60.2–65.7)	64.5 (61.7–67.3)	59.4 (56.7–62.1)
Total	225.2 (223.2–227.2)	216.7 (214.8–218.6)	201.1 (199.3–202.9)	67.2 (66.1–68.2)	66.8 (65.8–67.8)	59.7 (58.7–60.6)

Data are presented as standard ratio (95% CI).

Abbreviations: AMI, acute myocardial infarction

TABLE 2 Age-standardized hospitalization rates for acute myocardial infarction in a population aged 65 years or older before (2009–2010) and after (2011–2012 and 2013–2014) smoking ban introduction

Place of residence (number of residents; rates per 100 000)	Age-standardized hospitalization rates for AMI (confidence intervals)					
	Men			Women		
	2009–2010	2011–2012	2013–2014	2009–2010	2011–2012	2013–2014
Rural area	1019.0 (1002.3–1035.6)	1019.1 (1002.6–1035.5)	954.5 (939.0–970.0)	567.7 (558.2–577.1)	565.5 (547.2–565.8)	516.8 (508.0–525.6)
Towns (2000 to <100 000)	1444.2 (1420.8–1467.5)	1377.4 (1355.7–1399.1)	1257.5 (1237.7–1277.2)	807.1 (794.5–819.7)	762.0 (750.2–773.9)	689.8 (678.9–700.7)
Towns (100 000–200 000)	1313.0 (1270.8–1356.3)	1256.4 (1216.2–1296.6)	1165.8 (1129.7–1201.8)	696.3 (673.4–719.1)	685.9 (663.8–708.1)	618.5 (598.6–638.5)
Towns (200 000–500 000)	1245.3 (1208.5–1282.1)	1220.2 (1185.3–1255.2)	1130.9 (1098.4–1163.5)	699.6 (679.2–720.0)	647.4 (628.3–666.4)	592.2 (574.3–610.1)
Towns (>500 000)	1182.0 (1152.0–1211.9)	1210.1 (1180.6–1239.7)	1142.8 (1115.1–1170.5)	626.2 (610.1–642.2)	634.4 (618.6–650.3)	604.4 (589.3–619.4)
Total	1209.5 (1198.1–1220.8)	1192.8 (1181.8–1203.7)	1108.8 (1098.6–1118.9)	669.5 (663.3–675.8)	648.9 (642.8–655.0)	598.7 (593.0–604.3)

Data are presented as standard ratio (95% CI).

Abbreviations: see TABLE 1

statewide ban only in 2003. Hospital admissions for AMI were significantly reduced after 2003.[16] In countries where smoking ban implementation was a one-step process, long-term (over 1-year) reductions in AMI admissions ranged from 21% to 47%.[11,18] In Portugal, a reduction in the rates of AMI admissions was still observed even after 7 years, which was also attributed to the introduction of a smoking ban.[19] Notably, Sargent et al[20] reported an increase in the rate of AMI admissions following the revoking of the ban. In general, total smoking bans were shown to be more effective than partial restrictions.[21]

In Poland, in the years 2009 to 2014, a decrease in the total number of tobacco smokers from 29.2% to 26.1% was previously demonstrated.[22] The second-hand smoke exposure in Poland also decreased significantly in public places from 36% in 2009 to 12% in 2011,[12] which could translate into decreased rates of AMI hospitalizations. A recent systematic review of 21 studies showed that educational programs, clinician-related factors (such as time to provide counseling), and smoking bans were related to smoking cessation among smokers.[23] In a population-based study conducted in Geneva (Switzerland), a significant decrease in the rate of smokers after implementation of a public smoking ban was observed. However, the decrease was only temporal and coincided with a subsequent increase in the number of active smokers.[24]

Lee et al[25] found that the second-hand smoke exposure was associated with smoke-free laws and not with an urban or rural setting. This may result from the positive effect of actions aimed to improve public awareness of the adverse effects

of smoking. In our study, the total rates of AMI hospitalizations decreased markedly in both sexes and age groups. However, a long-term decline in the rates of AMI hospitalizations was observed almost in the entire country, except for people living in bigger towns (>200 000 and >500 000 inhabitants for women and men, respectively). These results are in line with other studies that showed a higher reduction in the rate of AMI admissions in men.[26] In Portugal, the effect of the smoking ban was greater in men and in people aged 65 years or older.[19] In England, after the introduction of smoke-free laws, the rate of AMI hospitalizations was significantly reduced in individuals aged 60 years or older (both men and women) as well as in men, but not women, younger than 60 years.[14] In a mathematical model, Richiardi et al[27] also showed that the impact of smoke-free laws on the rate of AMI hospitalizations was lower in women (2.4%–7.2%) than in men (3.6%–10.9%). This might indicate a considerable continued exposure to tobacco smoke in large towns and the need for further antitobacco campaigns, focused especially on younger women.

A long-term decline in the rates of AMI hospitalizations could be confounded by reductions in other major cardiovascular risk factors, such as a decrease in mean cholesterol levels, improvement of blood pressure control, or reduction of active smoking.[28-30] There are numerous factors at the individual and organizational levels that may influence smokers' compliance with a smoking ban, such as personal attitudes or levels of nicotine dependence. Changes in other risk factors might have also impacted the reduction of hospitalization rates observed during the years 2009 to 2014. In Poland, the incidence of CVD remains excessively high compared with other European countries, which may influence the effects of public smoking bans.[22]

Several limitations of this study have to be acknowledged. First, as noted above, to assess the long-term impact of smoking ban implementation on the rates of AMI hospitalizations, other cardiovascular risk factors should be identified and considered. However, in Poland, cardiovascular risk factors are assessed within 5- to 10-year periods, and such assessments were not carried out at the time of the study. Nevertheless, during the study, no new legal regulations or national programs for prevention of cardiovascular risk factors were introduced. Second, in order to observe trends in the number of hospitalizations due to AMI, a longer period before the introduction of the smoking ban would have to be considered, while the AMI-PL database was started only in 2009. Finally, we could not assess changes in active smoking behaviors following the smoking ban. As we could not analyze the smoking status of our group, we could not assess the effect of the ban on smokers in comparison with nonsmokers. Previous studies have shown that nonsmokers might benefit more from public smoking bans than smokers.[31]

In conclusion, after the introduction of the smoking ban in public places in Poland in November 2010, the rate of age-standardized AMI hospitalizations decreased markedly in the long-term follow-up both in men and women as well as both in younger and older individuals. The reduction in the rates of AMI hospitalizations differed by the place of residence. No decrease in the rates of AMI hospitalizations was observed in the first 2 years following the introduction of the smoking ban.

ARTICLE INFORMATION

CONTRIBUTION STATEMENT KO, AW, BW, MG, TZ, JS, MG, LP, and GO contributed to the concept and design of the study as well as to the acquisition, analysis, and interpretation of the data. KO and AW drafted the manuscript. BW, MG, TZ, JS, MG, LP, and GO critically revised the manuscript. All authors approved the final version of the manuscript and agreed to be accountable for all aspects of the work, ensuring its integrity and accuracy.

CONFLICT OF INTEREST None declared.

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