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Acute Myocardial Infarction Mortality Before and After State-wide Smoking Bans

Brad Rodu · Nicholas Peiper · Philip Cole

Abstract Rapid declines in hospital admissions for acute myocardial infarction (AMI) following smoke-free ordinances have been reported in smaller communities. The AMI mortality rate among persons age 45 + years (deaths per 100,000 persons, age-standardized to the 2000 US population) in the 3 years before adoption of the smoke-free ordinance (the expected rate) was compared with the rate observed in the first full year after the ban (the target year) in six US states. Target-year declines were also compared to those in states without smoking bans. Target-year declines in AMI mortality in California (2.0%), Utah (7.7%) and Delaware (8.1%) were not significantly different from the expected declines ($P = 0.16$, 0.43 and 0.89, respectively). In South Dakota AMI mortality increased 8.9% in the target year ($P = 0.007$). Both a 9% decline in Florida and a 12% decline in New York in the 2004 target year exceeded the expected declines ($P = 0.04$ and $P < 0.0002$, respectively) but were not significantly different ($P = 0.55$ and 0.08, respectively) from the 9.8% decline that year in the 44 states without bans. Smoke-free ordinances provide a healthy indoor environment, but their implementation in six states had little or no immediate measurable effect on AMI mortality.

B. Rodu (✉)
School of Medicine, University of Louisville, Room 208, 505 S. Hancock St., Louisville, KY 40202, USA
e-mail: brad.rodu@louisville.edu

N. Peiper
School of Public Health, University of Louisville, Louisville, KY 40202, USA

P. Cole
Department of Epidemiology, School of Public Health, University of Alabama at Birmingham, Birmingham, AL 35294, USA

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Introduction

In the past decade smoking bans have been implemented in many jurisdictions, and several published reports have claimed that bans result almost immediately in reductions in heart diseases. For example, in Helena, Montana hospital admissions for acute myocardial infarction (AMI) declined 40% in the six-month period following implementation of a smoke-free ordinance [1]. In Pueblo, Colorado, AMI admissions dropped 27% over a 1.5-year period following a smoke-free ordinance, and the authors reported that the decline occurred "within months" of the ban's implementation [2]. In Bowling Green, Ohio, hospital admissions for ischemic heart disease (IHD) and heart failure fell by 39% during the 12 months after implementation of a smoke-free ordinance [3]. In Monroe County, Indiana hospital admissions for AMI among non-smokers declined 71% in the 22-month period following a smoking ban [4].

Studies in Europe and Canada have also reported rapid AMI reductions after public smoking bans, although at magnitudes lower than those from the US. A study of hospitalizations in Scotland found a 17% decline 10 months after a smoking ban [5]. In 2005 Italy implemented a comprehensive smoking ban; AMI events declined about 11% both in Rome (after 1 year) [6] and in the Piedmont region (after 2–5 months) [7]. In Saskatoon, Canada hospital admissions for AMI declined 9% in the year following a smoke-free ordinance [8].

The purpose of this study was to test the hypothesis that smoking bans result in immediate, measurable reductions in AMIs. Between 1995 and 2003 statewide smoke-free

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ordinances were adopted by six states. We compared AMI mortality rates before and after the implementation of these statewide smoke-free laws.

Methods

We identified states that enacted smoke-free ordinances from 1995 to 2003 and the implementation date of each ordinance. We obtained state mortality rates for AMI among persons age 45 + years from the Compressed Mortality File from the National Center for Health Statistics (NCHS) [9]. We also obtained the rates for all other states (combined) that did not have state bans in the period of interest. The NCHS employed the 9th Revision of the International Classification of Diseases (ICD-9) through 1998 (AMI, 410.0–410.9); beginning in 1999 the agency used the 10th Revision (AMI, I21.0–21.9). All rates in this study are expressed as annual deaths per 100,000 persons and are age-standardized to the 2000 US population.

To evaluate the possible effect of each state's ordinance on its AMI mortality, we first determined the average annual change in the rate for each state over the three-year period prior to implementation of the ordinance. We used this average change to derive an expected mortality rate in the target year, which was the first full calendar year after the ban. The one-year effect period was similar to that of published reports.

The difference between the observed and expected AMI mortality rates was evaluated by the test for difference between two independent proportions [10]. We also compared the individual state AMI mortality rate changes to those of all other states (combined) without smoking bans during the period of interest. Thus, the target-year AMI mortality rate for each of the six states was compared both with the expected rate based on the three-year period prior to the ban (in which each state serves as its own control) and with the target-year rate among states without smoking bans, two different but informative benchmarks.

Results

Table 1 provides information about the implementation of each state ordinance, including the specific date, the target year, the population potentially protected by the ordinance and the actual number of AMI deaths in that year. Figure 1 shows age-standardized mortality rates for AMI among persons 45 + years during the relevant period for each of the six states, and for the US over the entire period from 1991 to 2004.

California and Utah—1995

The California ordinance went into effect on January 1, 1995, potentially affecting 9.1 million persons age 45 + years. From 1991 to 1994, the 3 years prior to the ordinance, the AMI mortality rate dropped from 225 to 204, an average annual decline of 3.0%. In the target year of 1995 the California AMI mortality rate declined only 2.0%, which was smaller than the expected decline ($P = 0.16$).

The Utah ordinance also became effective on January 1, 1995, potentially affecting 488,000 persons age 45 + years. In the 3 years prior to the ordinance the AMI mortality rate dropped from 200 to 180, a decline of 3.3% per year. In the target year (1995) the rate declined 7.7%, but this was not significantly greater than the expected decline ($P = 0.43$).

Between 1991 and 1994 the mortality rate for AMI declined from 292 to 259, or 3.8% per year in the other 48 states without smoking bans. In 1995 the decline was 3.9%, virtually identical to the expected decline ($P = 0.56$).

Table 1 Features of state smoke-free ordinances

State	Implementation date	Provisions	Target year[a]	Population age 45 + years (Millions)	AMI deaths[b]
California	January 1, 1995	Enclosed workplaces and restaurants without bars	1995	9.1	17,656
Utah	January 1, 1995	Enclosed indoor places of public access, bars exempted	1995	0.5	767
South Dakota	July 1, 2002	Most workplaces, bars and casinos exempted	2003	0.3	686
Delaware	November 27, 2002	Most indoor public places, including restaurants and bars	2003	0.3	433
Florida	July 1, 2003	Indoor workplaces, including restaurants	2004	7.2	10,073
New York	July 24, 2003	All workplaces, including restaurants and bars	2004	7.2	10,347

[a] Denotes the first full calendar year of enforcement

[b] Acute myocardial infarction

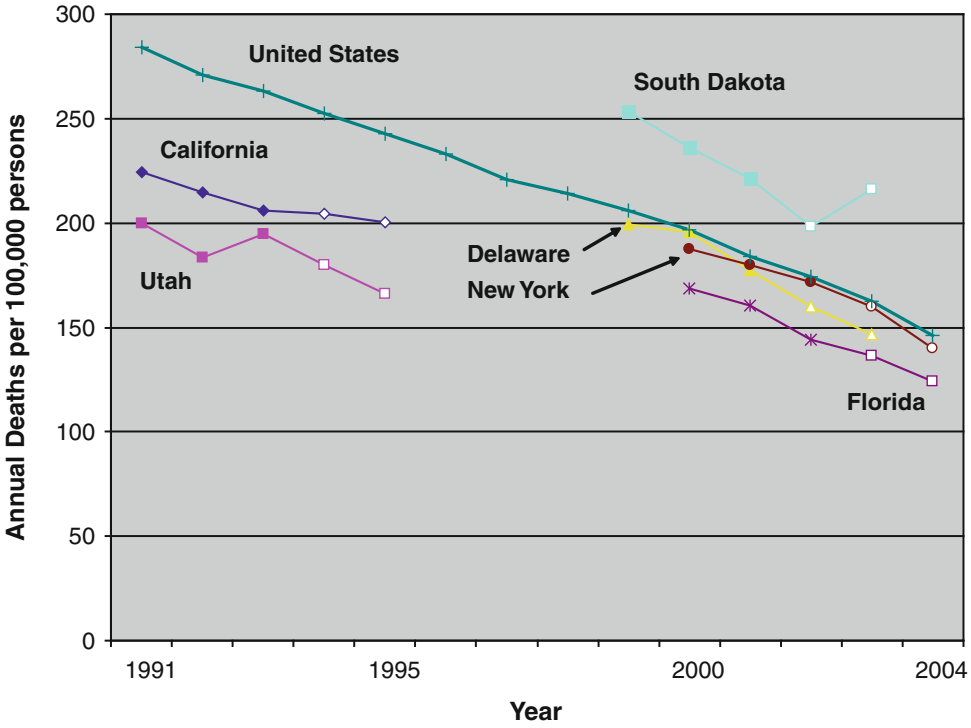

Fig. 1 Age-standardized mortality rate for acute myocardial infarction (AMI) among persons age 45 + years in states implementing smoke-free ordinances, and in the US, 1991–2004. Data points with white centers outline the slope of the change in AMI mortality during the target years

South Dakota and Delaware—2003

The South Dakota ordinance went into effect on July 1, 2002, potentially affecting 287,000 persons age 45 + years. In the 3 years prior to the ordinance the AMI mortality rate had dropped from 253 to 198, a decline of 7.2% per year. In the target year (2003) the rate increased by 8.9% to 216, which was significantly different from the expected decline of 7.2% ($P = 0.007$).

The ordinance in Delaware went into effect on November 27, 2002, potentially affecting 305,000 persons age 45 + years. In the 3 years prior to the ordinance the AMI mortality rate had dropped from 199 to 160, a decline of 6.6% per year. In the target year (2003) the rate declined 8.1%, which was not significantly greater than the expected decline ($P = 0.89$).

Between 1999 and 2002 the mortality rate declined from 210 to 178, or 5.1% per year for AMI in the other 46 states without a smoking ban. In 2003 the decline was 7.2%, which was significantly greater than the expected decline ($P < 0.0002$).

Florida and New York—2004

The Florida ordinance went into effect on July 1, 2003, potentially affecting 7.2 million persons age 45 + years. In the 3 years prior to the ordinance the AMI mortality rate had declined from 169 to 136, or 6.4% per year. In the target year (2004) the rate declined 8.8%, which was significantly greater than the expected decline ($P = 0.04$).

The ordinance in New York became effective on July 24, 2003, potentially affecting 7.2 million persons age 45 + years. In the 3 years prior to the ordinance the AMI mortality rate had declined from 187 to 160, or 4.9% per year. In the target year (2004) the rate declined 12%, which was significantly greater than the expected decline ($P < 0.0002$).

Between 2000 and 2003 the mortality rate for AMI declined from 206 to 169, or 5.9% per year in the 44 states without a smoking ban. In 2004 the decline was 9.8%, which was significantly greater than the expected decline ($P < 0.0002$).

Discussion

The major finding of this study is that state-wide smoke-free laws resulted in little or no measurable immediate effect on AMI death rates. The ordinances had no effect in California, Utah, Delaware or South Dakota (the AMI death rate actually increased almost 9% in South Dakota during the target year). Our results are consistent with a recent analysis finding that smoking bans were not associated with short-term declines in mortality or hospital admissions for myocardial infarction or other diseases [11].

The 9% decline in Florida and the 12% drop in New York exceeded expected declines based on historical trends

in those states, but they were not significantly different from the 10% decline in the 44 states that did not have smoke-free ordinances in 2004. The 12% decline in AMI mortality in New York is consistent with a statewide 8% decline in hospital admissions [12]. But an historic drop in AMI occurred throughout the US in 2004. Thus, attributing the state's drop in AMI admissions to the smoking ban may be inaccurate because 48 states showed declines in AMI mortality in that year. In fact, none of the previous reports have accounted for the long-term downward trend in heart disease morbidity and mortality.

In the present study state-based AMI mortality rates are derived from large populations and large numbers of deaths, but there was still considerable variation in the rate of decline from year to year (for example, the annual declines in Florida were 5, 10, 5, and 9% and those in New York were 4, 5, 7, and 12%). If the reports from Helena, Pueblo, Bowling Green and Monroe County accurately represent the impact of smoking bans on AMI incidence, large target-year declines in AMI mortality would have overwhelmed these year-to-year variations. Instead, the findings from these reports may be due to the random variation that occurs among groups of incidence statistics based on small numbers [13]. In Helena there were 40 and 24 admissions for AMI before and after the smoke-free ordinance; in Pueblo the corresponding numbers were 399 and 291; in Bowling Green, 36 and 22; and in Monroe County, 17 and 5.

This study's results are consistent with the fact that even the decline in active smoking has played only a minor role in reducing heart disease. A recent study evaluated the contribution of various factors to the decline in coronary heart disease mortality in the US between 1980 and 2000 [14]. It estimated that medical and surgical treatments accounted for half of the decline, while changes in all cardiovascular disease risk factors accounted for half. It also estimated that the decline in smoking prevalence accounted for only about 12% of the total decline in heart disease mortality, but even this percentage is subject to a small downward revision due to the association of smoking cessation with overweight/obesity, another cardiovascular risk factor.

There are some limitations to this study. Although using the same ICD codes for AMI that were used in the Helena and Pueblo reports, the outcome was AMI mortality instead of hospital admissions. However, if smoke-free ordinances produce significantly fewer hospital admissions for AMI, they should also result in significantly fewer deaths. Given the improvements in treatment for AMI described earlier, it is almost impossible to envision a scenario in which AMI mortality remains stable or increases while hospital admissions decline.

It is obvious that the public health impact of a smoke-free ordinance, if any, would be proportional to the population affected. While the ordinances in Delaware and New York covered workplaces, restaurants and bars, ordinances in the other four states covered only workplaces and restaurants. Both Helena and Pueblo implemented comprehensive smoke-free ordinances [1, 2], while Bowling Green's ordinance covered public places within the city except for bars and restaurants with bars in a separately ventilated area [3]. The Monroe County ban had an exception for bars [4].

The effect of a statewide smoke-free ordinance on AMI may have been muted if a large proportion of the population was already protected by pre-existing local ordinances. Such was the case in California, where city and county governments were very active in developing local ordinances, and by 1992 about 70% of the state's population was protected [15]. Most of these ordinances were enacted in the 1980s, so the AMI mortality rate in California might have declined more steeply than in the rest of the US during that decade. In fact, the opposite occurred. In the 1980s the age-adjusted AMI mortality rate in California declined at a slightly slower pace than the US rate.

New York State also had state and local ordinances dating back to the first statewide clean indoor air law in 1989. In fact, the New York State Department of Health estimated that 77% of the state population was protected in 2002 by local laws that were stronger than the existing state ordinance [16]. The study by Juster et al. [12] controlled for the effect of pre-existing local ordinances, estimating that a 19% decline in admissions would have resulted if none had existed prior to the 2003 ban.

Florida, New York and South Dakota implemented smoke-free ordinances in July, so the populations in these states were exposed to SHS for the first half of the year, and protected during the latter half. The expected effect would be a sharp decline in the state AMI mortality rate during the implementation year and a less prominent decline in the target year. The results did not follow this pattern. South Dakota experienced a 10% decline during the implementation year followed by a 9% increase in the target year. Both Florida and New York had smaller declines in AMI mortality during the implementation year (5 and 7%, respectively) than during the target year (9 and 12%, respectively).

Smoke-free ordinances may serve public health objectives by providing non-smokers with indoor environments that are free from irritating and potentially harmful pollutants. However, this study does not provide evidence that these ordinances result in a measurable immediate reduction in AMI mortality of the magnitude claimed by reports based on very small incident numbers.

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