# The Impact of Rhode Island's Statewide Smoke-Free Ordinance on Hospital Admissions and Costs for Acute Myocardial Infarction and Asthma

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A growing number of studies in the United States and other countries, and two meta-analyses, have demonstrated a decrease in the incidence of **acute myocardial infarction (AMI)**[1,2,3,4,5,6,7,8,9,10] and asthma[4,10,11] following the implementation of comprehensive smoking bans. These studies show a decrease in AMI admissions ranging from 8% to 40%, varying with the study design and methods. A statewide smoking ban in Arizona resulted in a 22% reduction in asthma hospital admissions in the year after implementation.[4]

In March 2005, Rhode Island implemented the Smoke Free Public Places and Workplaces Act,[12] a comprehensive statewide ban on smoking covering all enclosed public places of business, such as restaurants and bars, healthcare facilities, shopping areas, and offices. We used hospital discharge data to determine whether Rhode Island's statewide smoking ban reduced hospital admission rates and associated costs for AMI and asthma.

## Methods

Our analyses focused on adult admissions to one of Rhode Island's 11 acute care general hospitals where AMI (ICD-9-CM 410.xx), asthma (ICD-9-CM 493.xx), and appendicitis (ICD-9-CM 540.xx to 543.xx) were listed as the principal diagnosis. Patients under age 18 and out-of-state residents were excluded from analysis. We selected appendicitis as the control condition, as no known relationship exists between this condition and exposure to secondhand smoke. Age-adjusted hospitalization rates and 95% confidence intervals were calculated for each condition. The potential impact of the statewide smoking ban was examined in the two years immediately following the ban (Phase I: 2006-2007) and an additional two years after this period (Phase II: 2008-2009) to look for any sustained reductions in hospital admissions for AMI and asthma relative to the two years before implementation (2003-2004). Rhode Island's Hospital Discharge Data set also contains information on the total charges incurred for each patient's stay. The charges were multiplied by a cost factor ratio specific to each hospital in order to estimate costs or the amount reimbursed by health plans for hospital-based services. The total reimbursable costs were adjusted for inflation using 2009 as the reference year.[13] The percentage change (increase or decrease) in the total amount reimbursed for AMI, asthma, and appendicitis-related claims was calculated using the formula: ((Time 2 – Time 1)/Time 1)*100. We used this information to see if there were any changes in AMI and asthma costs that might be attributable to the statewide smoking ban. We ran the analyses with SAS software version 9.

**Table 1. Trends in age-adjusted hospital admission rates per 10,000 population for acute myocardial infarction, asthma, and appendicitis among Rhode Islanders 18 years and older, before and after implementing a statewide smoke-free ordinance, 2003-2009**

| | AMI[1] | Asthma[2] | Appendicitis[3] |
|---|---|---|---|
| Year | Rate (95% CI)[4] | Rate (95% CI) | Rate (95% CI) |
| Pre-implementation period | | | |
| 2003 | 35.2 (34.0 – 36.5) | 11.3 (10.6 – 12.1) | 7.9 (7.3 – 8.5) |
| 2004 | 31.5 (30.3 – 32.7) | 10.6 (9.9 – 11.3) | 8.7 (8.1 – 9.3) |
| Implementation period | | | |
| 2005 | 30.6 (29.4 – 31.8) | 12.8 (12.0 – 13.5) | 9.5 (8.8 – 10.2) |
| Phase I: post-implementation period | | | |
| 2006 | 28.1 (27.0 – 29.2) | 12.0 (11.3 – 12.8) | 9.3 (8.6 – 9.9) |
| 2007 | 25.2 (24.2 – 26.3) | 12.0 (11.2 – 12.7) | 10.0 (9.3 – 10.7) |
| Phase II: post-implementation period | | | |
| 2008 | 25.4 (24.3 – 26.4) | 12.6 (11.8 – 13.3) | 9.8 (9.1 – 10.5) |
| 2009 | 23.1 (22.1 – 24.1) | 13.5 (12.8 – 14.3) | 8.5 (7.9 – 9.1) |

1. Principal hospital admission for acute myocardial infarction (AMI), based on International Classification of Diseases, Ninth Revision codes (ICD-9-CM) 410.xx
2. Principal hospital admission for asthma, ICD-9-CM 493.xx
3. Principal hospital admission for appendicitis, ICD-9-CM 540.xx to 543.xx
4. CI = confidence interval

Data source: Rhode Island Hospital Discharge Data, Rhode Island Department of Health, Center for Health Data and Analysis.

**Table 2. Trends in reimbursed hospital costs for acute myocardial infarction, asthma, and appendicitis among Rhode Islanders 18 years and older, before and after implementing a statewide smoke-free ordinance, 2003-2009**

| | AMI[1] Total reimbursed costs[4] (n)5 | Asthma[2] Total reimbursed costs (n) | Appendicitis[3] Total reimbursed costs (n) |
|---|---|---|---|
| Pre-implementation | | | |
| 2003 | $44,789,782 (n = 3,062) | $4,718,725 (n = 946) | $4,215,489 (n = 641) |
| 2004 | 43,623,639 (n = 2,745) | $4,689,029 (n = 898) | $4,821,033 (n = 785) |
| Implementation | | | |
| 2005 | $44,681,044 (n = 2,664) | $5,824,679 (n = 1079) | $4,433,957 (n = 770) |
| Post implementation Phase I | | | |
| 2006 | $41,093,607 (n = 2,454) | $4,820,307 (n = 1,025) | $4,457,597 (n = 749) |
| 2007 | $37,138,862 (n = 2,220) | $5,327,521 (n = 1,023) | $4,975,899 (n = 795) |
| Post implementation Phase II | | | |
| 2008 | $37,863,172 (n = 2,261) | $6,039,936 (n = 1,074) | $5,219,772 (n = 781) |
| 2009 | $38,228,437 (n = 2,085) | $7,319,811 (n = 1,171) | $4,792,242 (n = 678) |
| Percentage change Pre-implementation (2003) to end of Phase I (2007) | -17.1 | +12.9 | + 18.0 |
| Percentage change Pre-implementation (2003) to end of Phase II (2009) | -14.6 | +55.1 | +13.7 |

1. Principal hospital admission for acute myocardial infarction (AMI), based on International Classification of Diseases, Ninth Revision codes (ICD-9-CM) 410.xx
2. Principal hospital admission for asthma, ICD-9-CM 493.xx
3. Principal hospital admission for appendicitis, ICD-9-CM 540.xx to 543.xx
4. The amount reimbursed for hospital based services by health plans adjusted for inflation.
5. n = number of hospital admissions.

Data source: Rhode Island Hospital Discharge Data, Rhode Island Department of Health, Center for Health Data and Analysis.

## Results

Table 1 shows the annual age-adjusted hospitalization rates for AMI, asthma, and appendicitis (per 10,000 population) for two years prior to and four years after the implementation of Rhode Island's statewide smoking ban. The largest reduction in AMI hospitalization rates was seen between 2003, when the rate was 35.2 per 10,000 population (95% CI 34.0 – 36.5), and 2009, when the rate was 23.1 per 10, 000 population (95% CI 22.1 – 24.1), a full four years after the ban prohibiting smoking in public places took effect. There was a significant increase in hospitalization rates for asthma between 2003 (11.3; 95% CI 10.6 – 12.1 and 2009 (13.5; 95% CI 12.8 – 14.3), but no change in the hospitalization rate for appendicitis over this time period (2003: 7.9; 95% CI 7.3 – 8.5; 2009: 8.5; 95% CI 7.9 – 9.1).

Table 2 shows the number of hospital admissions and total reimbursed costs for each diagnosis during three periods—prior to the smoking ban, during the first post-implementation phase, and during the second post-implementation phase. During the first post-implementation phase, there was a reduction in the number of admissions for AMI and a 17.1% decrease in total costs between 2003 and 2007. This represented a potential savings in hospital costs of over seven million dollars. A modest drop in the number of admissions for AMI occurred between the period immediately following the ban and the second post-implementation phase; however, a 14.6% reduction in total costs associated with AMI occurred between 2003 (two years before the ban was implemented) and the end of 2009, with a potential savings of over 6 million dollars.

We observed an increase in the number of admissions for asthma and a 55% increase in total costs between the pre-implementation phase and the end of the ban's second phase in 2009. The study period saw a modest increase in both the number of admissions and total costs for appendicitis, with an 18% increase in total costs between 2003 and the first period following the ban (2007), and a 13.7% increase in total costs between 2003 and the second period following the ban (2009). We did not expect exposure to secondhand smoke to affect appendicitis admissions and costs.

## Discussion

A number of recent studies have demonstrated reductions in hospital admissions for AMI after the implementation of a smoking ban.[1-10] Our study showed a reduction in age-adjusted hospitalization rates for AMI after the implementation of a statewide comprehensive ban on indoor smoking, with a 17% reduction in AMI-specific hospitalization rates in the first post-statewide ban period (2006-2007). A strength of this study is that we assessed the potential effects of the ban in the two years immediately following its implementation and at one later time point, which showed sustained decreases in AMI hospitalization rates and associated costs.

Unlike other studies,[4,10,11] however, we did not find that asthma hospitalizations rates decreased. The severity of the recent economic crisis in Rhode Island likely amplified factors associated with asthma exacerbations, such as poverty and poor housing quality.[14] These factors may have contributed to the increase in hospital admissions for asthma.

As with any study there are limitations to the data. Rhode Island's Hospital Discharge Data do not include biomarkers for exposure to secondhand smoke or whether patients admitted to the hospital are smokers. As such, we do not know what propor-

tion of the decrease in AMI hospitalization rates is attributable to the decrease in exposure to secondhand smoke by non-smokers. Caution should be taken when interpreting the asthma and appendicitis results given that admissions numbers for these two conditions were relatively small compared to AMI admissions.

At least three policy and practice implications are relevant given the demonstrated effectiveness of statewide smoking bans on cardiovascular disease outcomes. First, physicians should advise all patients with cardiovascular disease, and especially those with coronary heart disease, to avoid indoor areas that permit smoking.[7,15] Second, with hookah bars becoming more prevalent in Rhode Island, physicians should warn patients and educate decision makers of the cardiovascular health dangers caused by active smoking and secondhand smoke in these indoor establishments. Finally, managers and residents of both private and public multi-unit housing should join the growing movement in Rhode Island to pass comprehensive smoke-free housing policies, as achieved by the Providence Housing Authority in the spring of 2011.

The results of our study add to the growing number of other studies showing concrete cardiovascular health benefits and potential health care cost savings gained by implementing a statewide ban on indoor smoking. Our findings may prompt other states to join the growing list of 35 U.S. states benefiting from smoke-free laws.[16]

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### Disclosure of Financial Interests

The authors and/or spouses/significant others have no financial interests to disclose.



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