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Original Research

# Clean Indoor Air Acts reduce the burden of adverse cardiovascular outcomes

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SUMMARY

*Objectives:* Second-hand smoke is associated with an increased risk of adverse health outcomes, such as acute myocardial infarction (AMI) and coronary heart disease (CHD). At present, 38 US states/territories have enacted Clean Indoor Air Acts (CIAAs). The purpose of the current study was to compare the prevalence of self-reported health outcomes on a state/territory-wide level 1 year prior to CIAA implementation and at least 1 year after CIAA implementation for each respective state/territory.

*Study design:* Pre-test, post-test study.

*Methods:* Seventeen states/territories with pre- and post-CIAA data were included in the current study. All data (AMI, CHD/angina, former and current smoker rates) were collected from the Behavioral Risk Factor Surveillance System (BRFSS) in the year prior to each state/territory's respective CIAA implementation (baseline) and 2009 (most recent year with BRFSS data).

*Results:* Between baseline and 2009, 10 states/territories (58.8%) had a significant decrease in the prevalence of CHD/angina or AMI, 11 states/territories (64.7%) had a significant decrease in the prevalence of current smokers, and three states/territories (17.7%) had a significant decrease in the prevalence of both current and former smokers. Six states/territories (35.3%) had a significant increase in the prevalence of former smokers.

*Conclusions:* State/territory-wide CIAAs are beneficial in reducing adverse cardiovascular health outcomes in the short term. The prevalence of AMI, CHD/angina, and former and current smokers decreased significantly following CIAA implementation. The current study adds further support for the passage and implementation of CIAAs on a state/territory-wide level. However, further studies need to be conducted to assess the long-term outcomes of CIAAs.

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## Introduction

Coronary heart disease (CHD) is the main cause of death in the USA,[1] and tobacco smoking is the main risk factor for CHD.[2] Evidence suggests that second-hand smoke (SHS) exposure – even in non-smoking adults – is associated with an increased risk for acute myocardial infarction (AMI), lung cancer, CHD and ischemic heart disease.[3–15] Some studies have even

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shown that the effects of SHS are nearly as large as those for chronic, active smoking.[10,16]

Evidence regarding the effects of SHS on adverse health outcomes prompted many countries from around the world, including England, Ireland, Italy, France and Uruguay, to implement countrywide Clean Indoor Air Acts (CIAAs).[3,8,11,17–22] These CIAAs prohibited smoking in most – if not all – enclosed public places.[3,8,11,17–22] In the USA, these CIAAs have only been implemented at the state and/or local levels.[23] San Luis Obispo, California was the first city in the USA to enact a CIAA that banned smoking in all public buildings, including restaurants and bars.[24] California was the first US state to implement a CIAA that banned smoking in all public places, including bars.[23,25] Based on studies in some of the aforementioned countries, states and cities, the 2010 Institute of Medicine report confirmed that SHS exposure is associated with poor cardiovascular outcomes.[26] However, the effect size of the CIAAs on poor cardiovascular outcomes in these studies remains controversial.[26] Therefore, the purpose of this study was to assess the effect of the CIAAs on the prevalence of AMI, CHD/angina, and former and current smokers in those states/territories with CIAAs 1 year prior to and at least 1 year after implementation.

## Methods

### Study design

A pre-test, post-test study design was used to compare the effects of CIAAs on the prevalence of AMI, CHD/angina, and former and current smokers.

### Behavioral risk factor surveillance system

The behavioral risk factor surveillance system (BRFSS) was established in 1984 by the US Centers for Disease Control and Prevention.[27] It is currently the largest telephone health survey in the world, with over 350,000 adults being interviewed each year in each US state/territory. The BRFSS collects data on self-reported health risk behaviors, preventive health practices, and healthcare access of adults aged $\geq$18 years.[27] For many states/territories, the BRFSS is the only available source of timely, accurate data on health-related behaviors.[27] BRFSS data can be used to identify emerging health problems, establish and track health objectives, and develop and evaluate public health policies and programmes.[27] The majority of the measures in the BRFSS have moderate to high validity and reliability.[28] Additionally, the BRFSS provides national estimates comparable to the National Health Interview Survey.[29]

### US state/territory selection

Some form of state/territory-wide CIAA has been implemented in 38 US states/territories (Table 1). However, seven of these states/territories were excluded from the present study because their CIAAs were implemented after 2008, and BRFSS data are only available up to 2009. An additional 14 states/territories were excluded because their CIAAs were implemented prior to 2006 and BRFSS data collection on the outcome variables (CHD/angina and AMI) began in 2005. Therefore, 17 states/territories were included in the current study (Table 1).

### Data collection

All data for the current study were collected from the BRFSS in the year prior to each state/territory's respective CIAA implementation (baseline) and from the most recent year in the BRFSS database (2009). Data were collected on the prevalence of AMI, CHD/angina, and former and current smokers. Data were obtained from BRFSS participants from the questions in Table 2.[27]

Of the 17 states/territories included in the current study, the average number of years between baseline and 2009 was 3.06 years. Five states/territories (Colorado, Hawaii, Nevada, New Jersey, Ohio) had an interval of 4 years, eight states/territories (Arizona, District of Columbia, Louisiana, Minnesota, New Hampshire, New Mexico, Puerto Rico, Utah) had an interval of 3 years, and four states/territories (Illinois, Iowa, Maryland, Pennsylvania) had an interval of 2 years between baseline and 2009.

### Population coverage

The population of the entire state/territory was protected by the CIAA in all 17 states/territories included in the current study.[30] In total, 86,531,447 people (28.2% of the US population) were covered by a CIAA (excluding Puerto Rico)[30,31] when the populations of all 17 states/territories were combined (Table 1).

### Statistical analysis

Z-test was used to test the difference in proportions to determine if rates for the outcome variables and/or former and current smokers changed significantly from baseline to 2009. $P < 0.05$ was considered to be statistically significant. All statistical tests were conducted using Statistical Analysis Software Version 9.2 (SAS Inc., Cary, NC, USA).

## Results

Ten of the 17 states/territories (58.8%) were found to have a significant decrease in the prevalence of CHD/angina (Arizona, District of Columbia, Hawaii, New Hampshire, New Jersey, New Mexico, Pennsylvania) or AMI (District of Columbia, Hawaii, Iowa, Minnesota, New Hampshire, New Jersey, Puerto Rico) between baseline and 2009 (Table 3).

Two states/territories (11.8%) had a significant increase in the prevalence of CHD/angina (Colorado and Louisiana) between baseline and 2009. Four states (23.5%) had an increase in the prevalence of AMI (Colorado, Louisiana, Nevada, Pennsylvania) between baseline and 2009, but these increases were not significant (Table 3).

Fourteen states/territories (82.4%) had a significant decrease in the prevalence of current smokers (Arizona,

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