Cardiovascular Consequences of Secondhand Tobacco Smoke Exposure in Youth

2016 Scientific Statement from the American Heart Association

David White, PhD
Ward Family Heart Center
Children’s Mercy Hospital

Disclosures

- I have no relevant financial relationships with the manufacturers(s) of any commercial products(s) and/or provider of commercial services discussed in this CME activity
- I do not intend to discuss an unapproved/investigative use of a commercial product/device in my presentation.

Terms and Definitions

- SHS – Secondhand Smoke
- Cotinine – a metabolite of nicotine found in biological fluids, is a commonly used marker of tobacco smoke exposure.34
- NHANES – National Health and Nutrition Examination Survey
- CVD – Cardiovascular disease
Prevalence – Adults Who Smoke

- In 1964, ~40% of adults in the US were smokers
  - 1/3 = women

- Decreased to an estimated 18% >45 million US adults still smoke (2015)
  - 500,000 die each year of tobacco smoke–related illnesses

Prevalence – Youth Exposed to Tobacco Smoke

- 24 million nonsmoking youth in the US are currently exposed to SHS

- Data from 2011 to 2012 NHANES
  - 41% of children
  - 34% of adolescents
    - Detectable serum cotinine levels (>0.05 ng/mL)
Prevalence – Youth Exposed to Tobacco Smoke

- Exposure to SHS is decreasing!
  - Sample: non-smoking middle school and high school aged adolescents who self-reported exposure to SHS
    - Declined 59% to 34% between 2000 and 2009

- Despite these significant declines in exposure to SHS over the past 30 years, ≈1 in 3 youth in the US is still exposed to SHS
Prevalence – Race/Ethnicity

- Exposed to SHS in 2011-2012 (NHANES)
  - 31 million non-Hispanic white non-smokers
    - 7 million children and adolescents
  - 12 million non-Hispanic black non-smokers
    - 3 million children and adolescents
  - 6 million Hispanic non-smokers
    - 2 million children and adolescents

Homa et al, MMWR, 2015
Prevalence – Race/Ethnicity

- For the same amount of exposure, cotinine levels are higher in younger children (compared with adults)
  - Higher exposure from faster respiratory rates
  - Inadequate cotinine metabolism

Prevalence – Socioeconomic Status

- NHANES data from 2011 to 2012
  - Poverty
    - Below the poverty level = 43% exposed
    - Above the poverty level = 21% exposed
  - Education
    - Grade 11 or less education = 28% exposure
    - College or graduate diploma = 12% exposure

Prevalence – Economic Impact

- Tobacco smoking related economic costs in the US exceed $289 billion per year
  - 2009-2012 SHS exposure = $5.6 billion in lost productivity

US Department of Health and Human Services, Health consequences of smoking – 50 year progress report, 2014
Prevalence – Economic Impact

- Children living with at least 1 smoker
  - Increased emergency department expenditures
  - Increased inpatient use
- Additional costs associated in pregnant women smoking tobacco or being exposed to SHS
  ≈$2 billion per year

Levy et al., BMC Health Serv Res, 2011
Hill et al., Tob Control, 2008
CDC, MMWR, 1997

Missouri Specific

Missouri Foundation for Health, 2007
Missouri County Level Study of Adult Tobacco Use and Related Chronic Conditions and Practices, Executive Summary

Missouri Specific

Missouri Department of Health and Senior Services, Missouri Youth and Tobacco, 2003–2013: A decade of progress in prevention
Missouri Specific

- Missouri Department of Health and Senior Services, Missouri Youth and Tobacco, 2003-2013: A decade of progress in prevention

<table>
<thead>
<tr>
<th>Year</th>
<th>Non-Smoker</th>
<th>Former Smoker</th>
<th>Current Smoker</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>52.0%</td>
<td>30.6%</td>
<td>17.4%</td>
</tr>
<tr>
<td>2005</td>
<td>57.5%</td>
<td>28.0%</td>
<td>14.5%</td>
</tr>
<tr>
<td>2010</td>
<td>63.6%</td>
<td>40.7%</td>
<td>29.6%</td>
</tr>
<tr>
<td>2015</td>
<td>72.4%</td>
<td>52.9%</td>
<td>47.1%</td>
</tr>
</tbody>
</table>

Kansas Specific

- 8.8% of Kansas adults were exposed to SHS at home in the past week
- 16.5% of Kansas adults live in households where smoking is allowed


- 1 in 4 (25.6%) Kansas adults who live in multi-unit housing were exposed to SHS from inside or outside their residential building within the past year
- 78% of adults think smoking should never be allowed indoors in restaurants

Outline

- Prevalence
- Tobacco Smoke in the Home
- Cardiovascular Dysfunction
- Other Health Consequences of Smoke Exposure
- Strategies to Reduce Exposure in the Home
- What we know about SHS in E-Cigarettes

SHS in the Home

- >98% of children and adolescents living with someone who smokes at home have detectable SHS exposure
  - Not much different than 1988

Kansas Specific

<table>
<thead>
<tr>
<th>Percentage</th>
<th>SHS Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>75.1%</td>
<td>SHS Exposure</td>
</tr>
<tr>
<td>30.0%</td>
<td>SHS Exposure</td>
</tr>
<tr>
<td>24.1%</td>
<td>SHS Exposure</td>
</tr>
<tr>
<td>25.7%</td>
<td>SHS Exposure</td>
</tr>
<tr>
<td>70.0%</td>
<td>SHS Exposure</td>
</tr>
<tr>
<td>31.8%</td>
<td>SHS Exposure</td>
</tr>
</tbody>
</table>

CDC. MMWR, 2010; Mannino et al., Chest, 2001
SHS in the Home

- Why such a high prevalence?
- Children have less control over home and social environments, leading to an increased likelihood of involuntary, confined exposure to SHS

<table>
<thead>
<tr>
<th>Time point</th>
<th>Children (age 3-11)</th>
<th>Adolescents (age 12-17)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994-1998</td>
<td>38%</td>
<td>35%</td>
</tr>
<tr>
<td>1999-2004</td>
<td>24%</td>
<td>20%</td>
</tr>
<tr>
<td>2007-2008</td>
<td>18%</td>
<td>17%</td>
</tr>
</tbody>
</table>

CDC, MMWR, 2008; CDC, MMWR, 2010

SHS in the Home

- Youth living with someone who smokes inside the home
- Prevalence of SHS exposure in the home
  - Rent housing = 37%
  - Owned housing = 19%
- Home smoking bans use is lower
  - Low income
  - Single parent
  - Lower educational attainment

Zhang et al., Tob Control, 2012
**SHS in the Home**

- Prevalence
- Tobacco Smoke in the Home
- Cardiovascular Dysfunction
- Other Health Consequences of Smoke Exposure
- Strategies to Reduce Exposure in the Home
- What we know about SHS in E-Cigarettes

**Chemical Composition of SHS**

- Effects of tobacco smoke depend on
  - Direct smoking or SHS
  - Distance of those exposed from source
  - Length of time from the constituents entering the environment to exposure
    - environmental SHS aging
  - Whether the SHS is mainstream or side stream smoke
Mainstream vs. Side stream Smoke

Chemical Composition of SHS

- CVD risk from SHS depends on the chemicals present in side stream smoke
- The precise composition of SHS depends on fluctuating conditions
  - pH
  - Atmospheric gas composition
  - Ambient temperature
  - Degree of combustion
Chemical Composition of SHS

- The toxicity of some constituents in sidestream smoke increases over time
  - Ambient environmental reactions in which certain compounds deposit onto surfaces
    - Third hand smoke
  - Other gas constituents remain suspended in air

Chemical Composition of SHS and Cardiovascular Disease

- Acute exposure
  - Endothelial function
  - Vasconstriction
  - Heart rhythm
  - Platelet function
  - Autonomic function
  - Inflammation

- Subacute exposure
  - Dyslipidemia
  - Reduced insulin sensitivity
  - Inflammation via oxidative stress
  - Endothelial dysfunction
  - Thrombosis

Chemical Composition of SHS and Cardiovascular Disease

- Cardiovascular effects of specific chemicals
  - **Nicotine**: hemodynamic alterations
  - **Acrolein**: oxidation, inflammation, atherogenesis, hypertension, and arrhythmia
  - **Crotonaldehyde**: plaque instability and thrombosis
  - **Cadmium**: inflammation
  - **Lead**: hypertension
  - **Particulate matter**: arrhythmias and inflammation
Chemical Composition of SHS and Cardiovascular Disease

- Exposure to carbon monoxide and metals is minimal through SHS
- Nicotine exposures are also quite low
  - Nicotine dissipates rapidly from SHS

Quick Review of Vascular Physiology – Endothelium

- Vascular endothelium plays a central role in cardiovascular homeostasis
  - Arterial tone
  - Cell proliferation
  - Platelet interaction
- A healthy endothelium maintains a normal dilator state and anti-thrombotic surface, while regulating processes are thought to play a key role in early atherogenesis

Methods to Assess Vascular Health

- Arterial flow-mediated dilatation (FMD)
  - Measures vasodilator response to shear stress
  - Endothelial release of nitric oxide
  - Platelet aggregation
- Has been shown to predict cardiovascular events
  - Inhibition of leukocyte adhesion
  - Smooth muscle cell proliferation
Quick Review of Vascular Physiology – Arterial Function

- Arterial function
  - The transmission of blood flow to downstream tissue capillary beds with minimal energy loss
  - Regulation of blood flow to tissue capillary beds
- Determined by the structure and function of large conduit and small resistance arteries

Methods to Assess Vascular Health

- Carotid artery intima-media thickness (CIMT)
  - CIMT captures the effect of accumulated cardiovascular risk factors to the arterial wall
    - 1-mm increase in CIMT measurement in adults, the hazard ratio for CVD increases by 2.5
- Other methods
  - Carotid-femoral pulse-wave velocity

SHS and Cardiovascular Dysfunction – Human Studies

- The acute effects of SHS on the coronary circulation in healthy young adults.

Otsuka et al., JAMA, 2001
SHS and Cardiovascular Dysfunction – Human Studies

- Celemajer et al., NEJM, 1996
- n=78 (age 15–30 years)
  - 26 active smokers
  - 26 who had never smoked but had been exposed to SHS for at least 1 hour daily for ≥3 years
  - 26 control subjects who were not SHS exposed or actively smoking

Celemajer et al., Circulation, 2007
Arterial endothelial dysfunction related to passive smoking might be at least partially reversible in healthy young adults.
SHS and Cardiovascular Dysfunction – Human Studies

- The effect of short-term SHS exposure on muscle sympathetic nerve activity
  - One smoke inhalation session increased resting muscle sympathetic nerve activity by ≈20%
- This finding could in part underscore the association between SHS exposure and blood pressure in children

Hausberg et al., Circulation, 1997

SHS and Cardiovascular Dysfunction – Human Studies

- Exposure to SHS has significant effects on endothelial and arterial function for many years after exposure
  - Damage can be equivalent or worse than active smoking
  - Some reversibility

Kallio et al., Cardiovasc Qual Outcomes, 2010
SHS and Arrhythmia

- Schuetz and Eiden, Infant Behav Dev, 2006
  - Neonates with in utero SHS exposure had higher heart rates and lower heart rate variation with breathing than those in the non-exposed group

- Dixit et al., Heart Rhythm, 2016
  - SHS exposure in utero and during childhood was associated with atrial fibrillation later in life

SHS and Arrhythmia

- SHS exposure is associated with the release of epinephrine and norepinephrine
  - Similar to direct cigarette smoking
- Smoke exposure has a powerful sympathetic excitatory effect influencing sympathetic drive to blood vessels, skin, and the heart

SHS and SIDS

- The risk of SIDS is greater in infants if they are exposed in utero and/or in the postnatal period

- The risk of SIDS increases with increasing dose of SHS exposure
Outline

- Prevalence
- Tobacco Smoke in the Home
- Cardiovascular Dysfunction
- Other Health Consequences of Smoke Exposure
- Strategies to Reduce Exposure in the Home
- What we know about SHS in E-Cigarettes

SHS and Cardiometabolic Disease – Obesity

- The overall pattern appears to be one of lower weight at birth and larger postnatal weight gain
  – Longitudinal Healthy Start Study

SHS and Cardiometabolic Disease – Obesity

- The National Institute of Child Health and Human Development Study

Table 1: The effect of parental smoking and SHS exposure on the development of childhood obesity using generalized estimating equations (GEE).

<table>
<thead>
<tr>
<th>Smoking Status</th>
<th>No of Participants</th>
<th>% of Participants with Obesity, % (95% CI)</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parental Smoking</td>
<td>SHS Exposure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>Yes</td>
<td>150 (51.6)</td>
<td>27 (18.0)</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>140 (48.4)</td>
<td>16 (11.4)</td>
<td>1.0 (0.8-1.2)</td>
<td>1.0 (0.8-1.3)</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>130 (45.5)</td>
<td>12 (9.2)</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>No</td>
<td>No</td>
<td>140 (48.4)</td>
<td>20 (14.3)</td>
<td>1.0 (0.8-1.2)</td>
<td>1.0 (0.8-1.3)</td>
</tr>
</tbody>
</table>
SHS and Cardiometabolic Disease – Dyslipidemia

SHS and Academic Performance

- Children exposed to SHS have higher rates of adverse behavioral and cognitive effects, including ADHD
  - Children living with adults who smoke at home are absent from school 1.5 more days a year than children living with nonsmokers.

SHS and Academic Performance

- Max et al., School Health, 2014
  - SHS costs to the education system may be 4 times higher than the annual healthcare cost attributable to ADHD
  - Caregivers’ time tending to children absent from school is estimated to cost $227 million each year.
Outline

- Prevalence
- Tobacco Smoke in the Home
- Cardiovascular Dysfunction
- Other Health Consequences of Smoke Exposure
- Strategies to Reduce Exposure in the Home
- What we know about SHS in E-Cigarettes

SHS Reduction Strategies

- Intervention strategies fall into 2 broad groups
  - Directly minimize SHS exposure to children
  - Indirectly minimize SHS exposure by assisting parents/caretakers to quit or reduce smoking

- The majority of studies have targeted parents rather than non-parental caregivers.

SHS Reduction Strategies

- Interventions that directly minimize SHS exposure to children
  - Counseling and materials for parents
    - Not to allow smoking in the home, car, and around their children
    - Remove the child from rooms in the home or other locations when smoking is taking place
  - Hygienic smoking
SHS Reduction Strategies

- Interventions that directly minimize SHS exposure to children
  - Use of air cleaners
  - Biochemical feedback (cotinine measurement)

Are these interventions successful?
Rosen et al, Pediatrics, 2014
- Parent reported exposure (n=17)
- Cotinine (n=13)

Parent reported = ‘small benefits’
Objective measures (cotinine) = no effect

Are these interventions successful?
n=57 studies

Only 14 studies showed significant intervention treatment effect
SHS Reduction Strategies

In home and/or in car smoking bans

Cartmell et al, Public Health Rep, 2011

SHS Reduction Strategies

Missouri Department of Health and Senior Services, Missouri Youth and Tobacco, 2003-2013; A decade of progress in prevention

Figure 21

Missouri Health and Tobacco, 2007-2013: High School
Percentage of students who live in homes where smoking is allowed
Think smoking should never be allowed in homes

Missouri Department of Health and Senior Services, Missouri Youth and Tobacco, 2003-2013; A decade of progress in prevention
SHS Reduction Strategies

- 67% of Kansas adults who live in multi-unit dwellings favor rules prohibiting smoking in shared common areas.


SHS Reduction Strategies

- Percent of students who live with someone who smokes cigarettes:
  - 31.7%
  - 28.4%

- Percent of students who reported that smoking is not allowed in their homes:
  - 91.3%

- Percent of students who think that smoking should not be allowed in their homes:
  - 91.3%

- Percent of students who believe that smoking is less harmful in the past week:
  - 26.7%

- Percent of students who think that smoking is less harmful to their health:
  - 32.9%

- Percent of students who think that smoking is less harmful to their health:
  - 32.9%

Kansas Youth Tobacco Survey, 2011-2012

SHS Reduction Strategies – CEASE Program

1. www.ceasetobacco.org

CEASE
## CEASE Program

**CEASE Implementation Guide**

**Want Even More?**

<table>
<thead>
<tr>
<th>CEASE Program</th>
<th>CEASE Implementer Guide</th>
<th>CEASE Implementation Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>Identify the child and family</td>
<td>Determine the needs and strengths of the child and family</td>
</tr>
<tr>
<td></td>
<td>Early intervention</td>
<td>Early intervention services for the child and family</td>
</tr>
<tr>
<td></td>
<td>Child and family support</td>
<td>Child and family support services for the child and family</td>
</tr>
<tr>
<td></td>
<td>Assessment</td>
<td>Assessment for the child and family</td>
</tr>
<tr>
<td></td>
<td>Education Improvement</td>
<td>Education improvement services for the child and family</td>
</tr>
<tr>
<td></td>
<td>Family Engagement</td>
<td>Family engagement services for the child and family</td>
</tr>
<tr>
<td></td>
<td><strong>Step 2</strong></td>
<td>Identify the child and family</td>
</tr>
<tr>
<td></td>
<td>Early intervention</td>
<td>Early intervention services for the child and family</td>
</tr>
<tr>
<td></td>
<td>Child and family support</td>
<td>Child and family support services for the child and family</td>
</tr>
<tr>
<td></td>
<td>Assessment</td>
<td>Assessment for the child and family</td>
</tr>
<tr>
<td></td>
<td>Education Improvement</td>
<td>Education improvement services for the child and family</td>
</tr>
<tr>
<td></td>
<td>Family Engagement</td>
<td>Family engagement services for the child and family</td>
</tr>
</tbody>
</table>

### THANK YOU!

**QUESTIONS?**