

Brief Report

# National and State Estimates of Secondhand Smoke Infiltration Among U.S. Multiunit Housing Residents

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## Abstract

**Introduction:** Multiunit housing (MUH) residents are susceptible to secondhand smoke (SHS), which can infiltrate smoke-free living units from nearby units and shared areas where smoking is permitted. This study assessed the prevalence and characteristics of MUH residency in the United States, and the extent of SHS infiltration in this environment at both the national and state levels.

**Methods:** National and state estimates of MUH residency were obtained from the 2009 American Community Survey. Assessed MUH residency characteristics included sex, age, race/ethnicity, and poverty status. Estimates of smoke-free home rule prevalence were obtained from the 2006–2007 Tobacco Use Supplement to the Current Population Survey. The number of MUH residents who have experienced SHS infiltration was determined by multiplying the estimated number of MUH residents with smoke-free homes by the range of self-reported SHS infiltration (44%–46.2%) from peer-reviewed studies of MUH residents.

**Results:** One-quarter of U.S. residents (25.8%, 79.2 million) live in MUH (state range: 10.1% in West Virginia to 51.7% in New York). Nationally, 47.6% of MUH residents are male, 53.3% are aged 25–64 years, 48.0% are non-Hispanic White, and 24.4% live below the poverty level. Among MUH residents with smoke-free home rules (62.7 million), an estimated 27.6–28.9 million have experienced SHS infiltration (state range: 26,000–27,000 in Wyoming to 4.6–4.9 million in California).

**Conclusions:** A considerable number of Americans reside in MUH and many of these individuals experience SHS infiltration in their homes. Prohibiting smoking in MUH would help protect MUH residents from involuntary SHS exposure.

## Introduction

Exposure to secondhand smoke (SHS) from burning tobacco products causes disease and premature death among non-smokers (U.S. Department of Health & Human Services, 2006). Including the District of Columbia (DC), the number of U.S. states with comprehensive smoke-free laws prohibiting tobacco smoking inside all worksites, restaurants, and bars increased from 0 in 2000 to 26 in 2010 (Centers for Disease Control and Prevention, 2011). However, as public settings are increasingly made smoke-free, private settings such as homes are becoming relatively larger contributors to total SHS burden.

Multiunit housing (MUH) residents are particularly susceptible to involuntary SHS exposure in the home. Environmental studies conducted in MUH buildings indicate that SHS constituents can infiltrate smoke-free units and shared areas from units where smoking is permitted (Bohac, Hewett, Hammond, & Grimsrud, 2011; King, Travers, Cummings, Mahoney, & Hyland, 2010), and findings from self-reported surveys suggest that 44%–53% of MUH residents with smoke-free home rules have experienced an SHS infiltration in their living unit that originated from elsewhere in or around their building (Henrikus, Pentel, & Sandell, 2003; Hewett, Sandell, Anderson, & Niebuhr, 2007; King, Cummings, Mahoney, & Hyland, 2010; Licht, King, Travers, Rivard, & Hyland, 2012).

Although some studies have assessed the prevalence of SHS infiltration among MUH residents (Henrikus et al., 2003; Hewett et al., 2007; King, Cummings, et al., 2010; Licht et al., 2012), the characteristics of MUH residents and the number who are potentially susceptible to SHS infiltration is uncertain. This study calculated national and state estimates of the number of U.S. MUH residents, their sociodemographic characteristics,

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and how many of these individuals have experienced an SHS infiltration in their home.

## Methods

### Design and Sample

Estimates of MUH residency were determined by using national and state representative data from the 2009 American Community Survey (ACS), an annual household survey conducted by the U.S. Census Bureau. The sampling frame includes all valid residential addresses in the 50 states and DC. The ACS is primarily a mail-based survey; however, if no response is received, follow-up is attempted via computer-assisted telephone and in-person interviews. In 2009, 1,917,748 respondents were interviewed (one per household). The overall response rate was 98.0%; state-specific response rates ranged from 94.9% to 99.4% (U.S. Census Bureau, 2012).

Estimates of smoke-free home rule prevalence were obtained from the 2006–2007 Tobacco Use Supplement to the Current Population Survey (TUS-CPS), a cross-sectional household survey of adults conducted by the U.S. Census Bureau. Data were collected from approximately 240,000 respondents in May 2006, August 2006, and January 2007, with overall response rates ranging from 80.0% to 85.0% across the three data collection periods (National Cancer Institute, 2012).

### Measures

For this analysis, a MUH resident was defined as any respondent who reported living in a “one-family house attached to one or more houses,” or a building with between “2” and “50 or more” apartments. Respondents were not considered MUH residents if they reported living in a “one-family house detached from any other house,” “a mobile home,” or “boat, RV, van, etc.” Sociodemographic characteristics included sex, age, race/ethnicity, and poverty status. Poverty status was defined by using 2009 U.S. Census Bureau thresholds. Respondents were classified as having a smoke-free home rule if they reported that smoking was prohibited inside their home.

### Analysis

For each state and the United States overall, the number of MUH residents with smoke-free home rules was determined by multiplying the prevalence of adults with self-reported smoke-free home rules (TUS-CPS) by the respective number of MUH residents (ACS).

The number of MUH residents who have experienced an SHS infiltration in the home was determined by multiplying the national and state-specific number of MUH residents with smoke-free home rules by a range of 44%–46.2%. This range was derived from all published peer-reviewed studies that have assessed self-reported, past year SHS infiltration among MUH residents with a smoke-free home rule, either during or after the period (2006–2009) when the TUS-CPS and ACS data were collected (King, Cummings, et al., 2010; Licht et al., 2012). To ensure comparability with ACS estimates, studies of specific MUH subpopulations (e.g., public housing) were not considered in the infiltration range.

In both of the studies that were used to determine the prescribed range, the extent of SHS infiltration was calculated among MUH residents with a smoke-free home rule. However, different questions were used to define SHS infiltration. In Licht et al. (2012), which was fielded in 2010, respondents were considered to have experienced SHS infiltration if they responded “most of the time,” “often,” “sometimes,” or “rarely” to the question, “In the past 12 months, how often has tobacco smoke entered your unit from somewhere else in or around your building?” In King, Travers, et al. (2010), which was fielded between 2007 and 2009, SHS infiltration was defined as a response of “daily,” “a few times a week,” “once a week,” “once every couple of weeks,” or “once a month or less” to the question, “During the last 12 months of living in your unit, how often has SHS entered into your living space from somewhere else in or around the building?”

## Results

In 2009, 25.8% of U.S. residents (79.2 million) lived in MUH. By state, the proportion of MUH residents ranged from 10.1% in West Virginia (184,000) to 51.7% in New York (10.1 million) (Table 1). The proportion of MUH residents in DC was 83.5% (501,000). Among all U.S. MUH residents, 22.1% lived in one-family attached homes, 13.6% lived in apartment buildings with 2 units, 52.3% lived in apartment buildings with 3–49 units, and 12.0% lived in apartment buildings with 50 or more units (data not shown).

By sex, 47.6% of U.S. MUH residents were male and 52.4% were female (Table 2). Most MUH residents were aged 25–64 years (53.3%), followed by those aged 18–24 (12.8%), ≥65 (11.2%), ≤4 (8.4%), 5–11 (8.3%), and 12–17 (6.1%) years. By race/ethnicity, the greatest proportion of MUH residents were non-Hispanic White (48.0%), followed by Hispanic (23.0%), non-Hispanic Black (19.2%), non-Hispanic Asian (6.8%), and other non-Hispanic races (3.0%). A total of 24.4% of MUH residents lived below the federal poverty level.

An estimated 62.7 million U.S. MUH residents had smoke-free home rules. Assuming a prevalence of SHS infiltration between 44% and 46.2%, approximately 27.6–28.9 million MUH residents with smoke-free home rules experienced an SHS infiltration in their home within the past year. By state, estimates of SHS infiltration ranged 26,000–27,000 in Wyoming to 4.6–4.9 million in California (Table 1).

## Discussion

### Summary and Significance

The findings from this study reveal that over one-quarter of the U.S. population (79.2 million individuals) resides in MUH and that disparities in MUH residency exist across subpopulations. The findings also show that an estimated 27.6–28.9 million MUH residents with smoke-free home rules have potentially experienced an SHS infiltration in their living unit that originated from elsewhere in or around their building. Separating smokers from nonsmokers, cleaning the air, and ventilating buildings cannot eliminate exposure of nonsmokers to SHS. Therefore, policies prohibiting smoking in MUH, including

**Table 1. Estimated Number of Multiunit Housing (MUH) Residents, MUH Residents With Smoke-free Home Rules, and MUH Residents who Experienced Secondhand Smoke Infiltration in their Home in the Past Year, by State**

State	MUH population <sup>a</sup> (%)	MUH population <sup>a</sup> (n)	MUH population with smoke-free home rule <sup>b</sup> (n)	MUH population with SHS infiltration in home <sup>c</sup> (n)
Alabama	12.6	593,297	443,193	195,000–205,000
Alaska	28.5	199,065	161,840	71,000–75,000
Arizona	19.6	1,292,772	1,091,100	480,000–504,000
Arkansas	12.9	372,739	251,599	111,000–116,000
California	32.0	11,827,732	10,562,165	4,647,000–4,880,000
Colorado	23.9	1,200,915	1,018,376	448,000–470,000
Connecticut	31.8	1,118,816	917,429	404,000–424,000
Delaware	27.0	238,983	190,708	84,000–88,000
DC	83.5	500,714	377,037	166,000–174,000
Florida	27.1	5,023,790	4,265,197	1,877,000–1,971,000
Georgia	18.4	1,808,575	1,468,563	646,000–678,000
Hawaii	37.0	479,216	405,896	179,000–188,000
Idaho	12.9	199,408	176,277	78,000–81,000
Illinois	31.0	4,002,227	3,021,681	1,330,000–1,396,000
Indiana	15.2	976,313	678,538	299,000–313,000
Iowa	16.2	487,273	363,505	160,000–168,000
Kansas	16.6	467,912	364,503	160,000–168,000
Kentucky	15.4	664,373	403,939	178,000–187,000
Louisiana	15.8	709,748	535,150	235,000–247,000
Maine	19.4	255,750	196,416	86,000–91,000
Maryland	40.0	2,279,791	1,871,709	824,000–865,000
Massachusetts	39.8	2,624,248	2,138,762	941,000–988,000
Michigan	16.3	1,625,066	1,165,172	513,000–538,000
Minnesota	21.8	1,148,035	933,352	411,000–431,000
Mississippi	11.8	348,336	251,847	111,000–116,000
Missouri	16.2	969,988	683,842	301,000–316,000
Montana	14.6	142,348	116,583	51,000–54,000
Nebraska	16.9	303,629	243,814	107,000–113,000
Nevada	25.8	681,916	570,082	251,000–263,000
New Hampshire	25.0	331,144	269,551	119,000–125,000
New Jersey	38.4	3,343,772	2,785,362	1,226,000–1,287,000
New Mexico	15.1	303,460	240,037	106,000–111,000
New York	51.7	10,102,931	7,728,742	3,401,000–3,571,000
North Carolina	15.8	1,482,180	1,090,884	480,000–504,000
North Dakota	23.5	152,008	119,935	53,000–55,000
Ohio	19.5	2,250,816	1,553,063	683,000–718,000
Oklahoma	12.2	449,820	322,971	142,000–149,000
Oregon	22.8	872,250	756,241	333,000–349,000
Pennsylvania	33.4	4,209,992	3,031,194	1,334,000–1,400,000
Rhode Island	35.6	374,942	291,330	128,000–135,000
South Carolina	13.5	615,768	467,983	206,000–216,000
South Dakota	16.3	132,418	104,213	46,000–48,000
Tennessee	15.4	969,623	684,554	301,000–316,000
Texas	20.4	5,055,590	4,186,028	1,842,000–1,934,000
Utah	19.8	551,345	508,340	224,000–235,000
Vermont	21.0	130,570	99,886	44,000–46,000
Virginia	26.5	2,088,886	1,666,931	733,000–770,000
Washington	22.8	1,519,436	1,329,507	585,000–614,000
West Virginia	10.1	183,797	115,057	51,000–53,000
Wisconsin	24.1	1,362,801	1,031,640	454,000–477,000
Wyoming	14.9	81,096	59,362	26,000–27,000
United States	25.8	79,207,690	62,653,283	27,567,000–28,946,000

Note. DC = District of Columbia; MUH = multiunit housing; SHS = secondhand smoke.

<sup>a</sup>Estimated percentage and number of U.S. residents who live in MUH (American Community Survey).

<sup>b</sup>Estimated number of MUH residents with a smoke-free home rule (derived from Tobacco Use Supplement to the Current Population Survey data).

<sup>c</sup>Estimated number of MUH residents with a smoke-free home rule exposed to SHS (lower bound: 44.0%; upper bound: 46.2%).

**Table 2. Sociodemographic Characteristics of Multiunit Housing Residents, by State—American Community Survey, 2009**

State	Sex (%)		Age in years (%)						Race/ethnicity (%)					Poverty status (%) <sup>a</sup>		
	Male	Female	≤4	5–11	12–17	18–24	25–64	≥65	NH White	NH Black	Hispanic	NH Asian	NH other	≥Poverty	<Poverty	Unknown
Alabama	43.6	56.4	9.5	9.2	5.1	18.1	48.0	10.1	44.4	45.8	5.2	2.6	2.0	61.0	38.8	0.2
Alaska	49.6	50.4	9.3	8.5	7.2	14.5	55.6	4.9	61.0	8.7	6.9	6.6	16.8	90.1	9.8	0.1
Arizona	49.6	50.4	10.4	8.9	5.8	13.8	50.9	10.2	48.3	6.3	36.4	3.1	5.9	71.6	28.0	0.4
Arkansas	43.7	56.3	11.0	8.9	5.5	18.1	45.8	10.7	54.2	30.8	9.7	1.9	3.4	59.6	40.1	0.3
California	49.2	50.8	9.0	9.2	7.0	11.4	54.8	8.6	32.8	8.1	41.9	14.2	3.0	77.4	22.3	0.3
Colorado	49.3	50.7	8.6	7.4	4.4	14.7	55.1	9.8	61.1	6.3	26.5	2.9	3.2	74.5	25.2	0.3
Connecticut	47.1	52.9	7.4	7.9	6.8	11.2	54.4	12.3	50.3	17.5	24.4	4.8	3.0	78.7	21.1	0.2
Delaware	47.1	52.9	8.2	9.0	7.2	10.8	54.0	10.8	43.2	37.3	12.2	4.7	2.6	81.2	18.0	0.8
DC	46.6	53.4	6.6	6.6	6.2	9.7	60.2	10.7	30.1	54.7	9.6	3.0	2.6	80.8	19.0	0.2
Florida	47.3	52.7	7.6	7.3	5.3	10.9	51.5	17.4	46.0	19.7	30.5	2.3	1.5	78.2	21.6	0.2
Georgia	47.1	52.9	10.0	9.2	6.4	14.9	52.8	6.7	33.4	45.1	15.0	4.2	2.3	69.1	30.5	0.4
Hawaii	50.0	50.0	8.3	7.9	5.5	11.6	55.7	11.0	27.3	3.7	9.0	33.0	27.0	84.7	15.1	0.2
Idaho	47.2	52.8	11.3	7.6	4.8	22.9	43.0	10.4	77.6	1.9	14.1	2.5	3.9	64.8	35.0	0.2
Illinois	47.7	52.3	7.9	8.2	6.0	11.5	55.0	11.4	45.4	23.3	23.0	6.5	1.8	76.9	22.8	0.3
Indiana	46.1	53.9	9.0	7.6	4.7	17.5	49.4	11.8	65.3	20.6	8.4	2.7	2.7	66.6	33.2	0.2
Iowa	47.0	53.0	7.5	6.5	3.7	21.5	44.9	15.9	81.9	6.9	5.8	3.0	2.4	71.4	28.4	0.2
Kansas	46.7	53.3	8.6	6.9	4.7	20.3	47.7	11.8	67.4	14.2	11.4	3.1	3.9	73.7	26.0	0.3
Kentucky	47.1	52.9	9.8	8.2	5.3	16.3	49.6	10.8	73.3	15.4	6.6	1.7	3.0	63.0	36.8	0.2
Louisiana	45.8	54.2	10.2	9.0	6.8	17.8	48.3	7.9	37.5	50.9	7.1	2.5	2.0	64.8	35.1	0.1
Maine	45.9	54.1	8.2	7.0	4.7	14.0	51.1	15.0	86.7	4.4	2.2	1.6	5.1	70.9	27.8	1.3
Maryland	47.0	53.0	8.4	8.6	6.6	10.1	56.0	10.3	39.8	42.6	9.5	5.3	2.8	85.0	14.7	0.3
Massachusetts	47.3	52.7	7.0	7.2	5.8	10.1	57.5	12.4	63.7	9.9	16.7	6.9	2.8	80.9	18.9	0.2
Michigan	45.4	54.6	7.0	6.5	5.4	16.0	50.3	14.8	62.9	24.1	5.6	4.5	2.9	68.3	31.4	0.3
Minnesota	46.7	53.3	7.7	6.5	4.4	15.1	51.3	15.0	71.5	12.4	7.3	4.8	4.0	76.6	23.1	0.3
Mississippi	45.1	54.9	11.8	10.2	6.4	18.8	45.4	7.4	31.6	60.6	4.2	1.6	2.0	56.3	43.1	0.6
Missouri	45.2	54.8	8.6	6.6	4.9	16.9	49.6	13.4	65.5	23.6	5.0	2.5	3.4	69.5	30.3	0.2
Montana	45.6	54.4	10.3	7.6	2.8	20.0	47.0	12.3	82.4	0.1	6.3	1.2	10.0	65.2	34.3	0.5
Nebraska	46.6	53.4	7.9	6.4	4.0	20.4	46.0	15.3	73.2	9.2	11.0	4.1	2.5	72.8	26.4	0.8
Nevada	50.9	49.1	9.1	9.5	6.3	10.6	54.5	10.0	43.8	11.8	34.3	5.6	4.5	75.9	23.6	0.5
New Hampshire	48.0	52.0	6.6	6.6	6.2	14.3	53.5	12.8	86.2	2.5	5.9	3.2	2.2	80.2	19.0	0.8
New Jersey	48.0	52.0	7.8	8.3	6.8	8.9	56.1	12.1	39.4	20.2	28.6	9.6	2.2	82.6	17.1	0.3
New Mexico	45.5	54.5	10.3	9.9	6.7	13.6	49.5	10.0	37.7	4.5	44.8	2.0	11.0	66.7	33.2	0.1
New York	47.5	52.5	7.2	8.2	6.9	9.7	55.7	12.3	41.5	20.6	26.1	9.7	2.1	79.2	20.6	0.2
North Carolina	45.8	54.2	8.7	8.0	5.5	17.9	50.6	9.3	47.5	34.7	11.5	3.1	3.2	70.1	29.6	0.3
North Dakota	46.4	53.6	6.7	5.7	2.1	24.9	45.4	15.2	85.4	3.1	3.4	1.2	6.9	76.5	23.5	0.0
Ohio	46.1	53.9	8.3	7.6	5.2	13.4	52.7	12.8	66.0	24.0	4.9	2.4	2.7	66.9	32.7	0.4
Oklahoma	48.5	51.5	9.9	7.9	4.6	20.5	46.8	10.3	58.2	16.8	11.9	2.4	10.7	64.1	35.5	0.4

Continued

Table 2. Continued

State	Sex (%)		Age in years (%)					Race/ethnicity (%)						Poverty status (%) <sup>a</sup>		
	Male	Female	≤4	5-11	12-17	18-24	25-64	≥65	NH White	NH Black	Hispanic	NH Asian	NH other	≥Poverty	<Poverty	Unknown
Oregon	48.1	51.9	8.9	8.3	5.2	15.5	52.1	10.0	67.9	3.2	19.7	4.3	4.9	70.3	29.4	0.3
Pennsylvania	46.6	53.4	7.3	8.1	6.8	11.4	52.5	13.9	61.6	22.1	10.2	4.0	2.1	77.2	22.4	0.4
Rhode Island	47.2	52.8	7.2	8.2	7.0	9.7	54.0	13.9	60.6	8.6	23.4	4.1	3.3	76.4	23.4	0.2
South Carolina	45.7	54.3	9.4	9.7	6.0	15.8	49.6	9.5	49.4	40.2	6.1	2.3	2.0	67.1	32.4	0.5
South Dakota	44.5	55.5	9.0	6.1	2.4	21.3	43.8	17.4	79.8	2.7	3.7	3.0	10.8	72.5	27.4	0.1
Tennessee	45.8	54.2	9.8	8.2	5.7	15.1	51.5	9.7	57.0	31.4	7.5	2.1	2.0	64.2	35.4	0.4
Texas	49.5	50.5	10.7	10.0	6.2	15.0	51.5	6.6	32.9	18.6	41.9	4.8	1.8	68.5	31.2	0.3
Utah	49.4	50.6	10.7	8.1	4.4	23.9	45.2	7.7	72.2	1.7	19.1	3.3	3.7	71.6	28.2	0.2
Vermont	45.9	54.1	7.4	5.6	4.7	17.4	50.5	14.4	91.8	2.5	1.4	1.3	3.0	77.5	22.3	0.2
Virginia	47.5	52.5	8.9	8.0	5.8	13.0	56.0	8.3	47.3	27.3	13.3	8.7	3.4	82.9	16.7	0.4
Washington	48.0	52.0	8.2	7.3	5.4	14.4	54.5	10.2	63.7	6.6	15.2	8.5	6.1	76.3	23.4	0.3
West Virginia	45.5	54.5	8.1	5.0	4.2	21.5	49.5	11.7	84.6	6.9	2.1	1.8	4.6	59.2	40.8	0.0
Wisconsin	47.6	52.4	7.0	7.9	5.6	17.1	49.6	12.8	71.1	12.8	9.5	3.5	3.2	70.7	28.8	0.5
Wyoming	49.3	50.7	10.7	7.7	2.6	22.4	46.6	10.0	75.5	2.6	14.4	0.7	6.8	75.5	24.5	0.0
United States	47.6	52.4	8.4	8.3	6.1	12.8	53.3	11.2	48.0	19.2	23.0	6.8	3.0	75.3	24.4	0.3

Note. DC = District of Columbia; NH = non-Hispanic.

<sup>a</sup>Poverty status was defined using 2009 U.S. Census Bureau thresholds.

living units and indoor shared areas, represent the most effective way to fully protect MUH residents from involuntary exposure to SHS in this environment.

Smoke-free MUH policies are favored by most MUH residents (Hennrikus et al., 2003; Hewett et al., 2007; King, Cummings, et al., 2010; Licht et al., 2012), are legally permissible in both government-subsidized and market-rate housing (Schoenmarklin, 2009), and can result in cost savings for MUH operators (Ong, Diamant, Zhou, Park, & Kaplan, 2012). Moreover, the U.S. Department of Housing and Urban Development (HUD) has encouraged public housing authorities, as well as owners and management agents of multifamily housing rental assistance programs, such as Section 8, to adopt and implement smoke-free policies for some or all of their properties (HUD, 2009, 2010). Nonetheless, few MUH operators have implemented smoke-free policies, and many have misconceptions about implementation barriers (Hewett et al., 2007; King, Cummings, Mahoney, & Hyland, 2011). Therefore, initiatives to reduce SHS in MUH should include efforts to educate MUH operators about the benefits of smoke-free policies.

### Limitations

To our knowledge, this study is the first to report national and state estimates of MUH residency and SHS infiltration among U.S. MUH residents. Nonetheless, the findings are subject to at least four limitations. First, MUH residency and smoke-free home rule prevalence were determined from data collected at different times. However, it is unlikely that any significant changes in these estimates occurred during the 2-year period between which the data were collected. Second, smoke-free home rule estimates were obtained from the general population and may not be generalizable to MUH residents. However, estimates of smoke-free home rule prevalence among MUH residents are comparable to those of the general population (King, Cummings, et al., 2010; Licht et al., 2012; National Cancer Institute, 2012). Third, the SHS infiltration range used in this study was based upon data collected across multiple years (2007–2010). Since research suggests that the prevalence of smoke-free MUH buildings has increased with time (King et al., 2011), the inclusion of older data could lead to overestimation of SHS infiltration. In order to account for potential declines in SHS infiltration over time, the present analysis included only national and state representative studies conducted during or after the time period in which the MUH residency (2009) and smoke-free home (2006–2007) data were collected. Finally, the SHS infiltration range was based upon two studies conducted nationally and in one state (New York), which may limit generalizability to other states and subpopulations. Accordingly, future research could include state-level studies to verify and expand upon the measures and findings presented in this study.

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### Declaration of Interests

The authors have no competing interests to report.

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