

Tobacco Smoking by Occupation in Australia and the United States: A Review of National Surveys Conducted between 1970 and 2005

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Abstract: Tobacco use represents a key issue in workplace health, and much can be learned from countries where occupational smoking data has been regularly collected on a national basis. This article reviews national smoking surveys previously conducted in Australia and the United States between 1970 and 2005, and examines their relevance to the field of occupational tobacco control. When the first preliminary research was undertaken over 35 years ago, tobacco smoking was a regular feature in the general population of both countries, albeit with higher rates often documented among blue collar workers. Recent national investigations however, suggest that certain historical differences in smoking prevalence rates by occupation are persisting as we enter the 21st century. Detailed examination also indicates that employee sub-groups, such as cleaners and construction workers, are now bearing much of the occupational smoking burden in Australia and the United States. As such, there is an urgent need for more aggressive and finely targeted tobacco control activities in the workplace, as well as increased cooperation between tobacco control organizations, labor unions and other stakeholders, so that they may more effectively combat this ongoing threat to workers' health.

Key words: Smoking, Occupation, Tobacco, Australia, United States, Survey, Epidemiology

Introduction

Smoking represents a key issue in contemporary occupational health¹. Aside from tobacco use being a major cause of death worldwide², smokers are known to have greater absences from work, more sick days per year, and health care costs up to 50% higher than for comparable never-smokers^{3–5}. Employers bear a major burden when their staff smoke, such as higher ventilation costs, increased housekeeping and maintenance costs, decreased productivity due to smoking breaks, as well as fire insurance losses following the improper disposal of cigarettes^{6, 7}. Occupational tobacco use also harms other people at work⁸. For employees whose spouses do not smoke, the worksite represents one of the largest sources of environmental tobacco exposure⁹. Some studies suggest that passive smoking at work poses an even greater

risk of lung cancer for non-smokers, than passive smoking at home¹⁰. In this regard environmental tobacco exposure has now become an important labor issue, and the promotion of smoke-free surroundings comprises an essential component of any healthy and safe modern workplace¹¹. While tobacco use remains the single most preventable cause of lung cancer¹², contemporary reductions in lung cancer rates appear to have been preceded by a reduction in community smoking habits during the latter half of last century¹³. Quitting clearly offers major benefits for smokers, with Doll and colleagues¹⁴ showing that British physicians who quit by age 50 were able to reduce their smoking-related hazard by almost half. Smoking cessation programs in the workplace are also known to be beneficial for the employer and employee alike¹⁵, being more cost-effective than many forms of conventional medical care¹⁶, and having the potential to

decrease absenteeism and increase productivity among staff¹⁷).

Even so, one of the major historical conundrums in occupational tobacco control is the fact that smoking rates are not evenly distributed across all job categories¹⁸). Indeed, during recent years, growing disparities in tobacco consumption have become increasingly apparent across many occupational subgroups¹⁹). Although community smoking rates are declining in many countries, certain occupational groups, such as blue-collar workers, still continue to use tobacco at high rates when compared to their white collar counterparts¹⁹). Unfortunately, many of the impressive reductions in community smoking rates achieved last century have largely bypassed the blue collar workforce. Given the fact that the workplace represents an ideal location for anti-smoking programs among staff¹⁵⁻¹⁷), occupational smoking studies have an important role in identifying exactly which workplaces would most benefit from tobacco control interventions. In order to most effectively distribute and target preventive health care efforts at a national level therefore, accurate and up-to-date information on national tobacco smoking rates by job category are essential.

From an epidemiological perspective, there is also the critical issue of statistical confounding in occupational mortality studies, given the fact that tobacco plays such a major role in the development of many chronic workplace diseases. Smoking and occupation are known to be substantially confounded^{20, 21}), and a lack of accurate data may lead to biased assessments of the relationship between disease and occupational exposures²²), particularly when the occupational group under study smokes at rates differing from that of the control population²³). Furthermore, information on smoking habits is particularly hard to obtain if an occupational mortality study is based on registry data²⁴). For these reasons and more, accurate and *nationally-representative* data on tobacco smoking rates among specific industry groups forms an essential component of all research in the field of modern occupational epidemiology.

In many ways, Australia and the United States (US) have long been at the forefront of occupational tobacco control initiatives. Australia is now regarded as one of the most difficult markets for tobacco corporations to operate in, with an aggressive and well-organized anti-smoking movement and a wide variety of anti-smoking laws²⁵). The US, particularly California, has long been a battleground for public health versus tobacco companies, with well-researched antismoking campaigns and the introduction of smoke free bars representing two important public health achievements in this regard²⁶). As a result, community smoking rates in Australia and the US (especially in California), are now some of the lowest in

the world²⁶). Both countries also have an impressive history in the collection of national smoking datasets and its subsequent application to public health initiatives, such as the promotion of smoke-free workplaces. The aim of the current study therefore, was to review all national tobacco smoking surveys conducted in Australia and the US that had included smoking data stratified by occupational subcategories.

Methods

This study involved an extensive literature review of all scientific manuscripts which contained national smoking data from Australia and the United States, and which had also stratified their results by occupation. To clearly elucidate the overall smoking habits of workers in these countries, only nationally-representative studies were included. The earliest research of this nature appears to have begun during the early 1970s, with the most recent having been conducted in 2005. An internet search of Medical Subject Headings (MeSH) 'smoking', 'tobacco', 'occupation' and 'national' was undertaken using the National Library of Medicine *PubMed* database. After identifying some initial studies, the search was repeated using keyword variations such as 'smoke', 'workplace', 'blue collar workforce', and so on. Manuscripts located using the initial criteria were subsequently examined to find additional publications in their reference lists, a technique which was particularly successful, as a reasonable degree of historical cross-referencing had been undertaken by some authors. Manuscripts were listed in two tables (Australia and the US) and arranged by year in which the survey was undertaken, rather than the publication year. Smoking rates were listed as the prevalence of smoking by gender and occupational group, with all smoking prevalence rates and survey response rates rounded to the nearest whole number. A total of fourteen national surveys fitting the inclusion criteria appear to have been conducted in Australia between 1974 and 2005. In the United States, a similar number of investigations had also been performed, with the earliest study from 1970, and the most recent in 2004. As such, the current review summarizes these national surveys and their impact on the field of occupational smoking epidemiology between 1970 and 2005.

Tobacco Smoking by Occupation in Australia

The first basic prevalence data on tobacco use in the Australian population appears to have been conducted as early as 1945, when approximately 72% of males and 26% of females were smokers²⁷). From an epidemiological perspective however, the methodologies employed by

Table 1. National surveys of tobacco smoking rates by occupation in Australia: 1974–2005

Author (s) of Study ^a	Name of Survey and Surveying Body ^b	Year of Study ^c	Number of Participants ^d	Response Rate ^e	Age Range	Lowest Smoking Prevalence Rate ^f	Highest Smoking Prevalence Rate ^f
Gray & Hill ³⁵	Consumer Opinion Trends Survey (ACCV)	1974	[M] 3,316 [F] 3,037	n/s	≥16 yr	[M+F] Upper White Collar (36%)	[M+F] Lower Blue Collar (39%)
Gray & Hill ³⁷	Consumer Opinion Trends Survey (ACCV)	1976	[M] 2,044 [F] 1,829	n/s	≥16 yr	[M] Upper White Collar (31%)	[M] Lower Blue Collar (47%)
ABS ³⁸	Alcohol and Tobacco Consumption Patterns Survey (ABS)	1977	n/s	n/s	≥18 yr	Professional and Technical [M] 29% [F] 29%	[M] Miners, Quarrymen (71%) [F] Service, Sport & Recreation (40%)
Hill & Gray ³⁹	Consumer Opinion Trends Survey (ACCV)	1980	[M] 2,137 [F] 2,172	n/s	≥16 yr	[M] Upper White Collar (30%)	[M] Lower Blue Collar (47%)
Hill & Gray ⁴⁰	Consumer Opinion Trends Survey (ACCV)	1983	[M] 2,677 [F] 2,903	n/s	≥16 yr	[M] Upper White Collar (32%) [F] Upper White Collar (25%)	[M] Lower Blue Collar (43%) [F] Lower Blue Collar (36%)
Hill ⁴¹	Consumer Opinion Trends Survey (ACCV)	1986	[M] 4,537 [F] 4,903	n/s	≥16 yr	[M] Upper White Collar (23%) [F] Upper White Collar (17%)	[M] Lower Blue Collar (42%) [F] Lower Blue Collar (36%)
Salmon <i>et al.</i> ⁴²	Risk Factor Prevalence Survey (NHF)	1989	[M] 3,795 [F] 4,140	75%	20–69 yr	[M] Professional (17%) [F] Professional (17%)	[M] Less-Skilled (33%) [F] Less-Skilled (30%)
Hill <i>et al.</i> ⁴³	Consumer Opinion Trends Survey (ACCV)	1989	[M] 2,364 [F] 2,456	n/s	≥16 yr	[M] Upper White Collar (20%) [F] Upper White Collar (22%)	[M] Lower Blue Collar (43%) [F] Lower Blue Collar (31%)
Hill & White ⁴⁴	National Omnibus Survey (ACCV)	1992	[M] 3,063 [F] 2,983	n/s	≥16 yr	[M] Upper White Collar (14%) [F] Upper White Collar (19%)	[M] Lower Blue Collar (38%) [F] Lower Blue Collar (31%)
Hill <i>et al.</i> ⁴⁵	Consumer Opinion Trends Survey (ACCV)	1995	[M] 2,819 [F] 2,880	47%	≥16 yr	[M] Upper White Collar (17%)	[M] Lower Blue Collar (32%)
White <i>et al.</i> ⁴⁶	National Omnibus Survey (ACCV)	1998	[M+F] 7,852	n/s	>18 yr	[M+F] Upper White Collar (18%)	[M+F] Lower Blue Collar (40%)
Siahpush ⁴⁷	Household Expenditure Survey (ABS)	1998–99	[H] 6,898	77%	≥15 yr	[H] Professional (28%)	[H] Blue Collar (44%)
White <i>et al.</i> ⁴⁶	National Drug Strategy Household Survey (AIHW) ⁴⁸	2001	[M+F] 23,376	n/s	≥18 yr	[M+F] Upper White Collar (16%)	[M+F] Lower Blue Collar (36%)
Smith & Leggat ⁴⁹	National Health Survey (ABS) ⁵⁰	2004–05	[M+F] 26,000	90%	18–64 yr	Science, Building and Engineering Professionals [M] 8% [F] 3%	[M] Cleaners (52%) [F] Construction Tradespersons (49%)

^a Author of study and reference number in this manuscript, ^b ABS=Australian Bureau of Statistics, ACCV=Anti Cancer Council of Victoria, AIHW=Australian Institute of Health and Welfare, NHF=National Heart Foundation, ^c Year the data was collected, not the publication year, ^d Number of participants in the study (H=Households), ^e Response rates rounded to the nearest whole number (n/s=not specified), ^f Smoking prevalence rates rounded to the nearest whole number (M=Male, F=Female).

early researchers were not clear, and tobacco smoking rates were not stratified by occupation. Although few details were known about the smoking habits of Australians during this time²⁸), by the 1950s, it was suspected that tobacco use was probably a major threat to health. In 1953, the Medical Journal of Australia published its first article suggesting a link between smoking and lung cancer²⁹), and in 1962, the National Health and Medical Research Council (NHMRC) issued a statement describing a suspected relationship between cigarette smoking and lung cancer³⁰). By the early 1970s, increasing attention was being focused on the burden of occupational smoking in Australian workplaces. Although it was not a national survey as such, in 1973 Ferguson³¹) published one of the first studies of smoking, drinking and analgesic use among Australian workers, reporting that tobacco consumption was associated with major sources of mental and physical ill health. Later in 1981, Smith and colleagues³²) surveyed staff from 12 Australian workplaces and found that both the frequency and duration of sickness absences were greater in cigarette smokers and ex-smokers. As with Ferguson's earlier investigation however³¹), neither author had sourced their data from a national sample. McMichael and Hartshorne³³) conducted a retrospective mortality study of Australian workers between 1968 and 1978 with occupational stratification, although their tobacco use data was derived from another source.

The first large-scale epidemiological investigation of Australia's national smoking habits was conducted in 1974³⁴), and subsequently published by Gray and Hill in 1975³⁵). Their study included a broad stratification of job categories, from which some differences were evident in the smoking rates of 'upper white collar' workers (36%) when compared to 'lower blue collar' (39%) workers. High education was also shown to be associated with lower smoking prevalence rates, a precursor to later links that would be demonstrated between smoking duration, occupation and income³⁶). The survey reported by Gray and Hill³⁵) in 1975 was repeated between October and November 1976, and published by the same authors in 1977³⁷). As with the earlier investigation, males employed in the upper white collar occupations had the lowest smoking rates (31%), when compared to males working in the lower blue collar occupations (47%). Occupational data for females was not provided. Although these two investigations present what appears to have been the earliest data on occupational smoking rates in Australia, only broad divisions by job category (i.e. blue collar versus white collar) had actually been made.

The first detailed investigation of Australia's national smoking habits with specific delineation by job categories

was conducted by the Australian Bureau of Statistics in 1977³⁸), as their Alcohol and Tobacco Consumption Patterns survey. In this study, workers were stratified into nine specific occupational categories, as well as a tenth category titled: 'looking for a first job'. Results were presented as overall numbers and smoking prevalence rates by gender and also as an overall group. Both males and females working in the professional and technical fields had the lowest smoking rates (29% each). By contrast, males employed as miners or quarrymen (71%), and females in the service, sport or recreation industries (40%) exhibited the highest smoking prevalence rates within their gender subgroups³⁸). Overall, the ABS survey in 1977 suggested that at least 1 million Australian tradesmen, production workers, process workers, laborers, miners or quarrymen, were smoking cigarettes on a daily basis.

In 1980, a national survey of 4,309 Australians was conducted by the Anti-Cancer Council of Victoria³⁹). In this study the smoking prevalence rate by job category was listed for males only, among whom 30% of those employed in upper white collar occupations were smoking, compared to 47% of those in lower blue collar jobs. A 1983 survey published by Hill and Gray⁴⁰) found a slightly higher smoking prevalence rate of 32% among upper white collar males and 25% among upper white collar females. By contrast in the same study, almost half (43%) the Australian males employed in lower blue collar occupations and more than one-third (36%) of females in lower blue collar occupations, were current smokers. Although by 1986 the prevalence of smoking among male and female Australians employed in white collar occupations was declining (23% and 17%, respectively)⁴¹), the trend among those in lower blue collar occupations had remained relatively stable (42% and 36%). In 1988 Hill and colleagues³⁴) published a retrospective look at tobacco smoking among Australians between 1974 and 1986, finding that while the overall percentage of male cigarette smokers had fallen from 42% in 1974 to 32% in 1986, the decline among females was less impressive (30% in 1974 and 29% in 1986). Other trends had also been noticed during this period, with Australian tobacco consumption becoming increasingly synonymous with cigarette consumption²⁷). In the 1986 survey for example, Hill⁴¹) reported that only 1.4% of men smoked pipes or cigars exclusively, and that pipe or cigar smoking among Australian women was virtually non-existent.

Although they used slightly different classifications for occupational categories, Salmon and colleagues⁴²) analyzed data from the 1989 National Heart Foundation Risk Factor Prevalence Survey, and found that male and female professionals had the lowest smoking prevalence (17%

each), while those employed in ‘less-skilled’ occupations had the highest (males: 33%, females: 30%). In keeping with the design of earlier investigations, the Anti-Cancer Council of Victoria sponsored another national survey of tobacco smoking habits in 1989, which captured 4,820 Australian adults aged 16 yr and over⁴³). Similar to previous studies, the lowest smoking prevalence rates by job category were reported among those working in upper white collar occupations, where 20% of males and 22% of females smoked. The highest rates were again demonstrated in the lower blue collar occupations, where 43% of men and 31% of women smoked. In 1992 the Anti-Cancer Council of Victoria sponsored another national omnibus survey of tobacco smoking, this time capturing 6,046 participants with face-to-face interviews in their homes⁴⁴). As with previous surveys, there were marked differences in smoking rates by broad occupational category. For example, 38% of men in lower blue collar occupations were current smokers, compared to 20% of men in upper white collar occupations. A similar trend was also noted for women, where 31% of those in lower blue collar jobs smoked, compared to only 14% in upper white collar occupations. By 1995, Australian smoking rates in many subcategories, including occupational, had begun to slow or had simply ceased their decline. A nationally representative survey of 5,699 individuals found that while workers in the upper white collar occupations were now smoking at a slightly lower rate than before (with 19% of males and 17% of females smoking), the rate among lower blue collar female workers had actually increased slightly, from 31% to 32% between 1992⁴⁴) and 1995⁴⁵).

Although the national smoking rate of blue collar workers in Australia appeared to decline slightly in 1998, data from the Anti-Cancer Council of Victoria national survey was combined for males and females during White and colleague’s⁴⁶) analysis of the population. Another national survey was conducted between 1998 and 1999 by the Australian Bureau of Statistics in their household expenditure survey, which included items on smoking within households and also occupational status. From this data, Siahpush⁴⁷) reported that 28% of professional households contained a smoker, whereas among households with blue collar workers, the rate was 44%. White and colleagues⁴⁶) published a comparative analysis of Australian tobacco smoking trends between 1980 and 2001, including some previously unpublished data from the 2001 Australian National Drug Strategy Household Survey (NDSHS)⁴⁸). In their study, the authors found that overall, 36% of Australians in lower blue collar occupations were smoking, compared to 16% of those in upper white collar occupations. When compared to the results of previous surveys, it was noted that the difference in smoking preva-

lence rates between occupational groups had widened considerably in Australia between 1980 and 2001⁴⁶). Another study using data from the NDSHS also revealed that the smoking duration from onset to cessation among blue collar workers was 14% longer than for professionals³⁶). The first detailed analysis of Australian tobacco smoking rates by occupation appears to have been conducted by Smith and Leggat⁴⁹), using data from the 2004–05 National Health Survey (NHS)⁵⁰). In their study of 26,000 Australians, the authors revealed that among males, science, building and engineering professionals had the lowest smoking rates (8%), with cleaners having the highest prevalence (52%). Similarly for females, only 3% of science, building and engineering professionals smoked tobacco, compared to 49% of female construction tradespersons. As with previous investigations, this study demonstrated that although the prevalence of smoking among Australians has undergone a continuous decline since the mid-twentieth century, tobacco smoking habits are still not uniform across all Australian workplaces, with an increasing concentration among the blue-collar occupations.

Tobacco Smoking by Occupation in the United States

In 1954, Hammond and Horn published their first major article on smoking and death rates among American males⁵¹), followed by two more papers in 1958^{52, 53}) that would later become landmark articles in the field of tobacco smoking epidemiology⁵⁴). The first study of US smoking rates by occupation appears to have been conducted a little earlier than this however, between 1949 and 1952, although the main results were not published until October 1960⁵⁵). In their investigation of lung cancer cases in Californian hospitals, Dunn and colleagues⁵⁵) documented two concepts that would later become commonplace in the field of tobacco epidemiology. Firstly, they discovered that smoking prevalence rates varied depending on an individual’s occupation, and secondly, that most smokers self-evaluated their tobacco consumption in terms of ‘packs’ of cigarettes smoked per day. Another concept from this period that would later become a cornerstone in tobacco control epidemiology was the ‘Brinkman Index’ of smoking severity, first published by Brinkman and Coates in 1963⁵⁶). In their pioneering study of bronchitis and ventilation, the authors also documented differences in forced expiratory volume rates between different categories of workers, although individual smoking prevalence rates among them were not reported.

Other studies were also being conducted at around the same time. A community investigation from Michigan

Table 2. National surveys of tobacco smoking rates by occupation in the United States: 1970–2004

Author (s) of Study ^a	Name of Survey and Surveying Body ^b	Year of Study ^c	Number of Participants ^d	Response Rate ^e	Age Range	Lowest Smoking Prevalence Rate ^f	Highest Smoking Prevalence Rate ^f
Sterling & Weinkam ⁽⁶³⁾	National Health Interview Survey (NCHS)	1970	[M+F] 76,675	n/s	≥17 yr	[M] Professional, Technical and Kindred (31%)	[M] Operatives and Kindred (51%)
Sterling & Weinkam ⁽⁶⁴⁾	National Health Interview Survey (NCHS)	1970	[M+F] 75,827	n/s	≥17 yr	[WM] Clergymen (8%) [WF] Librarians (16%)	[WM] Roofers and Slaters (72%) [WF] Waitresses (50%)
Weinkam & Sterling ⁽⁶⁵⁾	National Health Interview Survey (NCHS)	I) 1970 II) 1979–80	I) 75,497 II) 34,800	n/s	≥17 yr	I) Professional [WM] 30% [WF] 28% II) Professional [WM] 23% [WF] 26%	I) Blue Collar [WM] 53% [WF] 36% II) Blue Collar [WM] 45% [WF] 36%
Levin <i>et al.</i> ⁽⁶⁶⁾	National Bladder Cancer Study (NCI) ⁽⁶⁷⁾	1977–78	[M+F] 5,782	[M] 83% [F] 81%	21–84 yr	[WM] Clergymen (6%) [WF] Farmers (7%)	[WM] Stationary Engineers (47%), [WF] Food Service Workers (36%)
Brackbill <i>et al.</i> ⁽⁶⁸⁾	National Health Interview Survey (NCHS)	1978–80	[M+F] 49,715	n/s	≥17 yr	[M+F] Farmers and Farm Managers (25%)	[M+F] Transportation Equipment Operatives (49%)
Stellman <i>et al.</i> ⁽⁶⁹⁾	Cancer Prevention Study: II (ACS)	1982	[M] 393,847 [F] 478,214	72%	45–70 yr	[M] Clergy (13%) [F] Farmer (11%)	[M] Law Enforcement (34%) [F] Waitresses (40%)
Novotny <i>et al.</i> ⁽⁷⁰⁾	National Health Interview Survey (NCHS)	1985	[W] 18,302 [B] 3,291	n/s	25–64 yr	[W] White Collar (28%) [B] White Collar (32%)	[W] Blue Collar (41%) [B] Blue Collar (44%)
Nelson <i>et al.</i> ⁽⁷¹⁾	National Health Interview Survey (NCHS)	I) 1978–80 II) 1987–90	I) [M+F] 28,640 II) [M+F] 82,358	I) n/s II) 85–90%	I) ≥17 yr II) ≥18 yr	I) [M+F] Clergy (11%) II) [M+F] Physicians (6%)	I) [M+F] Bartenders (65%) II) [M+F] Roofers (58%)
Lee <i>et al.</i> ⁽⁷²⁾	National Health Interview Survey (NCHS)	1987–94	[M+F] 141,122	95–98%	≥18 yr	[M+F] Physicians (4%)	[M+F] Roofers (58%)
Bang & Kim ⁽⁷³⁾	National Health and Nutrition Examination Survey (NCHS)	1988–94	[M+F] 20,032	86%	≥17 yr	[M+F] Educational Services (12%)	[M+F] Material Moving Occupations (46%)
Giovino <i>et al.</i> ⁽⁷⁴⁾	Current Population Survey (NCI)	1995–96	[M+F] 126,713	86%	≥18 yr	[W] White Collar (20%) [B] White Collar (17%)	[W] Blue Collar (38%) [B] Blue Collar (29%)
Giovino <i>et al.</i> ⁽⁷⁴⁾	National Health Interview Survey (NCHS)	1997	[M+F] 20,043	80%	≥18 yr	[M] White Collar (21%) [F] White Collar (20%)	[M] Blue Collar (37%) [F] Blue Collar (34%)
Barbeau <i>et al.</i> ⁽⁷⁵⁾	National Health Interview Survey (NCHS)	2000	[M+F] 24,276	72%	18–64 yr	[W] White Collar (21%) [B] White Collar (19%)	[W] Blue Collar (39%) [B] Blue Collar (28%)
Lee <i>et al.</i> ⁽⁷⁶⁾	National Health Interview Survey (NCHS)	I) 1987–94 II) 1997–04	[M+F] 298,042	I) 94–97% II) 70–80%	≥18 yr	Health Diagnosing Professions D) (6%) II) (5%)	I) Construction Laborers (43%) II) Construction Workers (39%)

^a Author of study and reference number in this manuscript, ^b ACS=American Cancer Society, NCHS=National Centre for Health Statistics, NCI=National Cancer Institute, ^c Year the data was collected, not the publication year, ^d Number of participants in the study, ^e Response rates rounded to the nearest whole number (n/s=not specified), ^f Smoking prevalence rates rounded to the nearest whole number (M=Male, F=Female, W=White, B=Black).

between 1959 and 1960 for example^{57, 58}), revealed that 62% of men working in blue collar occupations smoked tobacco, compared to 6% of men working in agriculture⁵⁷). Between 1964 and 1968 Friedman and colleagues⁵⁹) investigated the smoking rates of over 70,000 people, grouping their results by workplace ‘exposures’ rather than by occupation. Between 1977 and 1979 Covey and Wynder⁶⁰) interviewed around 2,500 males, finding that smoking intensity was higher among men involved in blue collar occupations. While the seed was certainly being sown during these early investigations, a dearth of nationally representative data remained. Nevertheless, the importance of national population statistics had been recognized by the US government somewhat earlier than this, with large-scale surveys having been conducted since at least 1935⁶¹). The US National Committee on Vital and Health Statistics was established by the Surgeon General in 1949⁶²), although it was not until the first National Health Interview Survey (NHIS) began in 1957, that comprehensive data on smoking rates within the general US population was collected.

The first nationally-representative study from the US that included occupational categories appears to have been conducted in 1970, using data from the NHIS of the same year⁶³). In their 1976 publication, Sterling and Weinkam⁶³) stratified smoking habits by occupation, and found that prevalence rates were highest among those in blue collar occupations and lowest among professionals, managers and proprietors. Later analysis of around 75,000 individuals from the same data set also revealed that smoking was more common among individuals in blue collar occupations⁶⁴). The NHIS was repeated between 1979 and 1980 finding that, when compared to the 1970 NHIS data, the pattern of occupation within smoking categories had remained basically unchanged⁶⁵). The authors also stated that the probability of young people taking up smoking was seemingly linked with eventual occupational choice. By absolute prevalence rate, 23% of white US males in professional occupations were smokers, compared to 53% of white US males working in blue collar jobs.

Levin and colleagues⁶⁶) analyzed population data from the 1977–78 National Bladder Cancer Study⁶⁷) finding that among white males, clergymen had the lowest smoking rates (6%) whereas stationary engineers (i.e. those who operate steam turbines, boilers or refrigeration machinery) had the highest rates (47%). Analysis of data from the 1978–1980 US National Health Survey by Brackbill and colleagues⁶⁸) found that when males and females were combined, farmers and farm managers had the lowest smoking rates, and transport equipment operatives the highest rates, with roughly half of them being current smokers. These authors also noted how the *indus-*

try in which people worked contributed somewhat to their relative differences in smoking rates by occupation. In their 1988 study for example, Brackbill and colleagues⁶⁸) reported that the broad industry in which one worked rather than the individual job title itself, was responsible for up to 25% of the differences seen in tobacco consumption rates. In 1988, Stellman and colleagues⁶⁹) published their analysis of the American Cancer Society’s, Cancer Prevention Study cohort. Similar to Levin and colleagues study four years earlier⁶⁶), and Sterling and Weinkam’s investigation eight years prior to that⁶⁴), Stellman and colleagues⁶⁹) also noted that clergymen had the lowest smoking prevalence rate among American males. Unlike the previous authors however, Stellman and colleagues⁶⁹) revealed that the highest cigarette smoking rate in their cancer prevention cohort (34%) was among law enforcement officers.

In 1988 Novotny and colleagues⁷⁰) analyzed data from over 20,000 respondents in the 1985 NHIS, finding that smoking rates were higher among blue collar workers, when compared to white collar workers and that black workers appeared to have a higher smoking prevalence rate than whites. A longitudinal analysis of NHIS data from 1978–80 and 1987–90⁷¹), found that although overall smoking rates had declined among blue-collar workers between 1978 and 1990, their smoking prevalence was still much higher than for white-collar workers. In the first part of their study during 1978–80, Nelson and colleagues⁷¹) reported that clergy had the lowest smoking prevalence rates by occupation (11%), and bartenders the highest (65%). By 1987–90, physicians were the least likely to consume tobacco (6%) and roofers the most likely (58%). Analysis of NHIS data between 1987 and 1994 by Lee and colleagues⁷²) also found that very few physicians smoked when compared to roofers (4% versus 58%). While overall rates of smoking among US workers were probably declining by the late 20th century, blue-collar workers continued to smoke in large numbers. Analysis of 20,032 respondents from the US NHANES study by Bang and Kim⁷³), revealed similar high rates of tobacco use among blue-collar workers at a national level. By specific occupation, males and females involved in educational services were the least likely to smoke, with workers of the material moving occupations the most likely (12% versus 46%).

In 1995–96 the US National Cancer Institute recruited over 100,000 citizens in its Current Population Survey. Similar to Novotny and colleagues in 1988⁷⁰), Giovino *et al.*⁷⁴) reported differences in the smoking prevalence rates of African-American workers versus white workers, and the smoking rates of those in white collar occupations compared to blue collar occupations. Analysis of another dataset by Giovino and colleagues⁷⁴), this time the 1997

National Health Interview Survey, also found gender differences in the smoking rates of white collar workers in the US (F: 20% versus M: 21%), and their blue collar counterparts (F: 34% versus M: 37%). In 2004, Barbeau and colleagues⁷⁵ published their analysis of the 2000 NHIS, which revealed that an individual's occupation still mattered, and the previously recognized gap between smoking rates among white collar and blue collar workers was persisting into the twenty first century. Interestingly, the authors found that among whites, the differences in smoking rates between white to blue collar workers (21% versus 39%) was a little wider than the differences between blacks (19% versus 28%)⁷⁵. The most recent national data on US smoking rates by occupation appears to have been published by Lee and colleagues in 2007⁷⁶. In their analysis of the 1987–94 and 1997–04 National Health Interview Survey data sets, the authors reported two interesting trends. Firstly, US workers in the health diagnosing professions were the least likely to smoke in both the 1987–1994 dataset (6%) and the 1997–04 dataset (5%). Secondly, the construction industry maintained the highest smoking rates overall, with 43% of construction laborers smoking in 1987–94 and 39% of construction workers smoking in 1997–04.

Aside from smoking prevalence rates, some authors also investigated tobacco smoking intensity among US workers on a national basis during the past 30 yr. Although the author did not describe prevalence rates as such, Leigh⁷⁷ nonetheless analyzed data from the US National Health Epidemiological Follow-up Survey of 1982–84, and found that the quantity of cigarettes smoked per day varied widely by occupation. Among males, production supervisors smoked the most and secondary school teachers the least, consuming an average of one and nine cigarettes per day, respectively. For women, those involved in door-to-door sales smoked the most (nine per day on average) while kindergarten teachers consumed the least (less than one cigarette per day, on average). Similarly, Covey and colleagues⁷⁸ reported that male nicotine dependent workers were more commonly found in the blue collar workforce, although the latter author's data was not nationally representative.

Discussion

Much can be learned about occupational smoking by looking at Australia and the United States, two countries where large, national surveys have been conducted for many years. Both regions also have a long history of tobacco consumption among their citizens. Tobacco leaves first came to Australia in 1788, and were being cultivated locally by 1803²⁸. The earliest national data on tobacco consumption reported that around 18 million

pounds were smoked in 1920, a figure which had risen to 58 million pounds by 1962²⁸). Cigarette smoking also became an ingrained habit in the US early last century, with per capita usage rising from 7 pounds in 1900, to 13 pounds in 1952⁷⁹). Tobacco consumption increased rapidly during the 1930s and 40s, and continued until the 1950s, when the first large-scale cohort studies linking lung cancer to smoking in America began to appear in the scientific literature^{51–54}). Although the prevalence of smoking among US adults has continually declined since 1965⁸⁰), as we enter the twentieth century tobacco smoking remains a major economic burden in the US, and continues to be responsible for one of the largest negative impacts on population health. In contemporary Australia, smoking contributes to more drug-related hospital separations and deaths than illegal drug use and alcohol consumption combined, and risks the future health of almost four million citizens who currently smoke⁴⁸). Similarly in American society, tobacco causes almost half a million premature deaths per year⁸¹). As the current review has shown, much of this burden continues to be shouldered by the working class in both countries.

Despite relatively continuous reductions in average smoking prevalence rates across the general population of Australia and the US during the twentieth and twenty-first century, this review suggests that a similar trend has not been consistently occurring within occupational groups. Although overall smoking rates in both blue collar and white collar workforces have evidently decreased somewhat, the magnitude of this decline has been uneven. Furthermore, in the Australian national surveys that stratified their data into similar occupational categories^{37, 39–45}), an increasing gap between white and blue collar smoking rates was also observed. In 1976 for example³⁷), the difference between male 'upper white collar' and 'lower blue collar' smoking rates was approximately 16%. When similar occupational groups were evaluated in 1995⁴⁵), the disparity had increased to 22%. While 19% of upper white collar males were still smoking in 1995 (compared to 31% in 1976 — a decline of 12%), for lower blue collar males the smoking rate remained high at 41% (compared to 47% in 1976 — a decline of only 6% over the same time period). Although the results from US surveys were less clear in this regard, due to slightly different occupational classifications being used, data from both countries nevertheless suggests that most tobacco-reduction gains appear to have been achieved in the white collar workforce. In ascertaining how and why such a phenomenon may have occurred on a national basis, albeit with data based on average or aggregate smoking rates, there are a few points worth considering.

Firstly, there is the issue of differing education levels,

given that this factor is strongly correlated with career choice, income, health behaviors and smoking. While most professional jobs have intrinsic educational requirements, the same does not always apply to many blue collar occupations. Disparities in the smoking rates of blue and white collar workers reflect not only these differences in education level, but also the larger structural forces which shape people's lives, beyond the work environment. Among low-income women for example, it has been suggested that smoking may be used as a means of coping with economic pressures⁸²). Health behaviors themselves are also well-known to independently affect other variables which influence employment. In a recent Danish study for example, Christensen *et al.*⁸³) found that female heavy smokers had an increased risk of long term sickness absence. Such situations may incur additional financial strain for precariously employed persons, potentially leading to further income reductions. Even when taking demographic variables such as these into account, the exact reasons why blue collar workers continue to smoke at higher rates than their white collar and professional counterparts, remains elusive, and relationships between the two are by no means clear-cut.

This leads to a second issue, that very few investigations have been able to ascertain whether people who are already smoking, go on to select certain occupations, or alternatively; whether working in a particular occupation actually encourages smoking. Certain demographic similarities between smokers may carry over to the workplace, and vice versa. From the current results at least, it could be surmised that an individual working in a construction or cleaning occupation in Australia or the United States would probably have many colleagues who smoked. In this manner, having a large proportion of the workforce who smokes probably makes it difficult for management to enforce smoking bans and instigate other tobacco control activities. This 'critical mass' of smokers as a group, may become strongly resistant to anti-smoking measures, regardless of their benefits for any one individual. Previous research among construction workers in the US for example⁸⁴), has suggested that there may be a low level of health promotion policy development with regard to smoking. As support will clearly be needed 'at the coal face', an expanded role for labor unions in the development of more healthy lifestyle practices for their constituents, would be a step in the right direction. For workers who already smoke prior to entering blue collar occupations however, a lack of support at the coal face may decrease the chances of successfully quitting, as coworker support is known to be very important in this regard⁸²). Furthermore, the coverage of smoking-cessation treatments by health and welfare funds is still believed to be suboptimal in some recent studies⁸⁵). This

may limit the uptake of quit smoking programs by certain sections of the workforce who simply cannot afford it, such as blue collar employees, thus creating an unbreakable cycle of smoking at work, compounded by an inability to quit.

Despite the wealth of published national epidemiological data from Australia and the United States, some important questions still remain with regard to occupational smoking research. Firstly, there is the issue of data representativeness, given the collection methods and techniques for ascertaining smoking status. As other authors have already described, there are both direct⁸⁶) and indirect methods⁸⁷) for gathering tobacco usage data, both with their inherent advantages and disadvantages. Smoking habits reported by individuals themselves have long been the core of national investigations, mainly due to cost-effectiveness, convenience and the fact that the validity and accuracy of such methods have been previously demonstrated^{88, 89}). Although response rates have generally been quite high for national surveys, it was noted as early as 1973 that questionnaire response times may vary depending on an individual's smoking status, with smokers being slower to respond than ex-smokers⁹⁰). Such epidemiological shortfalls therefore, may exist within any national studies of occupational tobacco use. Secondly, from a purely epidemiological perspective, it is difficult to draw causal or temporal inferences from cross-sectional prevalence data. The fact that blue-collar workers probably smoke tobacco more often than white collar professionals is only one of the differences between these two occupational groups²⁰). Thirdly, and perhaps most philosophical of all, there may be major differences between the workers who smoke tobacco and the epidemiological researchers who study them²⁰).

While all of these issues will clearly need to be considered in future national studies of tobacco smoking by occupation, it is difficult to ascertain how nationally-applicable strategies might practically move forwards. One method may be to link smoking data from national health surveys with other government databases containing detailed information on the characteristics of various occupations. The Occupational Information Network (O*NET) developed by the US Department of Labor for example, provides comprehensive information on key attributes and characteristics of workers and occupations⁹¹). Another option might be the Dictionary of Occupational Titles (DOT)⁹²), which uses data supplied by the US Department of Labor to classify occupational categories. A combined dataset of this nature would then lend itself to analysis which more clearly elucidates the job dimensions inherent in occupations with a high smoking rate. Even with more detailed data at hand, one of the key areas for future research will be the need for a

greater focus on socio-contextual factors in national tobacco research. Chief among them will be to ascertain why certain workers begin smoking at all, and also, why certain occupations do not cease smoking to the same extent as others. The addition of more in-depth and qualitatively-focused questions on the national health surveys of Australia and the US would clearly be a step in the right direction, and might afford a deeper and more useful approach to the problem. One practical approach, though expensive, would be to extract a random sample of national survey participants following the initial collection phase, and subsequently invite them for a short personal interview on health habits, work tasks, personal beliefs and so on. Combining these findings with the abovementioned stratification of job categories would help elucidate smokers' attitudes and beliefs at work, from a national perspective. Future intervention efforts to help reduce tobacco consumption in high-risk workplaces could then be customized on a national basis, to better meet the needs of occupational groups they are targeting.

Conclusions

An overall examination of previous national surveys from Australia and the United States suggests that there are persistent disparities in tobacco smoking rates by occupation. While Australia and the United States have long been at the forefront of tobacco control initiatives and have fairly low smoking rates in their general populations, it is disappointing to see that many of these hard won gains have bypassed certain sectors of the workforce. When the first preliminary research was undertaken over 35 yr ago, tobacco smoking was a regular feature in the general population of both countries, albeit with generally higher rates documented among blue collar workers. Recent national investigations however, suggest that the differences in smoking prevalence rates by occupation are still continuing as we enter the 21st century. Detailed data analysis (where it has been available) also indicates that employee sub-groups, such as cleaners and construction workers, now appear to be shouldering much of the tobacco-related health burden. As such, there is clearly an urgent need for more aggressive and finely targeted tobacco control activities in the workplace, as well as increased cooperation between tobacco control organizations and labor unions, so that they may more effectively combat this ongoing threat to workers' health.

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