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Smoking Inequality Trends by Disability and Income in Australia, 2001 to 2020

George Disney,[a] Dennis Petrie,[b] Yi Yang,[a] Zoe Aitken,[a] Lyle Gurrin,[c] and Anne Kavanagh[a]

Background: While policies to reduce smoking in many countries have been successful, disadvantaged groups (such as low-income groups) have only seen minor gains. People with disability are one such disadvantaged group and are more likely to smoke. However, evidence is limited on trends and inequalities in smoking for disabled people and on whether those also on low incomes are more likely to smoke.

Methods: We use annual data from 2001 to 2020 of the Household Income and Labour Dynamics in Australia survey. We use a Bayesian model to estimate smoking prevalence trends and inequalities for people with disability (2020, n = 1,370) and without disability (2020, n = 6,229) across the whole population and within income tertiles. To avoid reverse causation (smoking causing disability), we focus on younger people (15–44 years).

Results: Absolute reductions (per 100 people, [95% credible intervals]) in smoking were similar for people with (−13 [−16, −11]) and without disability (−15 [−16, −14]), with stable absolute but increasing relative inequalities. In the low-income group, absolute reductions in smoking prevalence for people with disability (−10 [−14, −6]) were smaller than in people without disability (−14 [−15, −12]), resulting in moderate evidence for increasing absolute inequalities (4 [0, 8]) and strong evidence for increasing relative inequalities. In high-income groups, disability-related absolute inequalities narrowed (−6 [−10, −3]), and relative inequalities were stable.

Conclusions: Disabled people in Australia, especially those on low incomes, show signs of being left behind in efforts to reduce smoking.

Keywords: Bayesian; Disability; Inequalities; Smoking; Socioeconomic status; Uncertainty

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Reducing smoking has long been a policy priority for public health agencies.[1] Smoking puts health at risk, showing strong evidence for increasing the incidence of lung and other cancers, heart disease, stroke, chronic respiratory disease, and other conditions.[2,3] In some countries, measures to drive down tobacco use, such as increased taxes,[4] have led to falling smoking rates in the general population. However, evidence suggests that these measures have not been universally successful. For example, there is evidence in Australia that tobacco tax increases have been less effective in disadvantaged groups.[5,6] There is also international evidence of smaller falls in smoking in some disadvantaged groups, such those on low incomes or with low levels of education, causing absolute and relative inequalities in smoking rates to rise.[7–9]

One commonly disadvantaged group is people with disabilities. We know that, in numerous countries, people with disabilities are more likely to smoke. In Australia, for example, people with disability are twice as likely to be daily smokers than people without disability.[10] In Europe there are clear inequalities, with higher smoking prevalence among disabled people[11] and in the United States, smoking prevalence among adults with disabilities was found to be 1.5–1.7 times higher than in adults without disabilities.[12,13] There is, however, very little research on how smoking for people with disabilities has changed over time, and whether their trend mirrors the trend in the population without disability.

Furthermore, disability is a multidimensional concept relating to body functions and health, activity limitations, the environment in which people live, and personal factors.[14] The population of people with a disability captured across and within data sources is likely to be diverse, and it is likely smoking prevalence could vary across disability subgroups. For example, we know that smoking prevalence is high among people with severe mental illness, and interventions have been tailored for this group,[15] among whom there could be people who are identified as having a psychosocial disability. Estimates of the prevalence of smoking among people with an intellectual disability,

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Household Income and Labour Dynamics in Australia survey data are available from the Australian Data Archive. Code is available upon request from the corresponding author.

The authors report no conflicts of interest.

SDC Supplemental digital content is available through direct URL citations in the HTML and PDF versions of this article (www.epidem.com).

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however, are varied.[16] Furthermore, a systematic review in 2013 found very little evidence to inform interventions to reduce smoking among people with intellectual disability,[17] and our own recent updated search using the same search terms found this has not changed, suggesting that health promotion policies and smoking cessation programs are not commonly tailored to meet the needs of people with intellectual disabilities.

It is also worth considering that people with disabilities are more likely to experience socioeconomic hardship, poverty, social exclusion, and unemployment[18–20] all of which are themselves associated with higher levels of smoking. It is thus hard to know to what extent any association between disability and smoking might simply be associated other forms of disadvantage people with disability face. Unstratified assessment of disability-related inequalities for the whole population may mask excess risk and inequalities in other subgroups, such as low-income people with disability.

To our knowledge, there is no research that quantifies smoking among those with and without disability by socioeconomic group. Such evidence would allow us to consider which barriers may be preventing further progress on reducing smoking.

To address these gaps in the literature, this article has two aims. Using data from a large, long-standing representative Australian panel survey, covering 2001–2020, our first aim is to estimate age-standardized smoking prevalence for people with and without disabilities, and to analyze how absolute and relative (shortfall) inequalities have changed over time (see Kjellsson et al[21] for full discussion of shortfall and attainment measures). Our second aim is to estimate smoking prevalence and inequalities for people with and without disability disaggregated by socioeconomic status. Given the likely diversity of disability in our sample, we also assess whether our results presented for aims one and two vary according to the disability subgroup. For aim one, the subgroups are sensory; psychological; intellectual; physical disability and acquired brain injury; and "other" disabilities. For aim two, due to the extra level of disaggregation by income tertile, we combine the psychological and intellectual groups and the "other" and sensory disability groups.

Presenting and assessing changes in prevalence, relative and absolute inequalities according to one social dimension (e.g., disability) is challenging, given the comparisons that need to be made (people with vs. without disability) and the three main outcome metrics (prevalence, relative, and absolute inequalities). Including further subgroups (e.g., by income tertile) increases this number of comparisons and adds complexity to our analysis. To address this challenge, we use visualization techniques for presenting prevalence and inequalities on both the relative and absolute scale simultaneously we have developed previously.[11,22,23]

Furthermore, when survey data are disaggregated to this extent (by disability, income tertile, and then standardized by age), we could run into familiar statistical problems associated with small sample sizes and there could be considerable uncertainty in our results. With that in mind, we also build on our previous work, which demonstrated how model estimates of trends in prevalence, relative, and absolute inequalities, and the uncertainty associated with these estimates, can be displayed simultaneously on one plot.[11] Visualizing the uncertainty in trends of prevalence and inequalities provides us with a tool to assess the strength of evidence of whether these trends are changing over time.

METHODS

Data Source

We use the Household, Income and Labour Dynamics in Australia (HILDA) survey. HILDA is a household-based panel study. It collects information on economic and personal well-being, labor market dynamics and family life.[24] HILDA covers all regions of Australia, except for very remote areas, and therefore underrepresents Aboriginal and Torres Strait Islander people, the Indigenous population of Australia. The sampling frame is also limited to private dwellings so is likely to underrepresent people with disability who live in communal settings.

The survey is conducted at the household level through a combination of face-to-face interviews and self-completion questionnaires. The first wave was in 2001, interviewing 7682 households made up of 13,969 individuals 15 years of age and older. The initial response rate was 66% and approximately 90% of these people continue to participate in the HILDA study. In Wave 11, a top-up of 5477 individuals was added to the original sample to include immigrants who arrived between 2001 and 2011 to join the HILDA Survey. The Department of Social Services granted ethical approval for HILDA analyses.

For this study, we use 20 waves of data from 2001 to 2020. We include all responses at each wave of the survey. To ensure our findings are representative of the Australian population, we use the cross-sectional weights from the HILDA data.[24]

While the main aim of this study is to describe inequalities in smoking between people with and without disabilities, we wanted to avoid these inequalities representing reverse causation (previous smoking causing the disability we observe) as much as possible. As such, we restrict our analysis to people aged 15–44 years old. We choose this age group as smoking in people under 50 years of age in Australia only accounts for 11% of the total disease burden attributable to tobacco use.[25] Restricting in this way will minimize the health harms of smoking being the underlying reason for people reporting a disability.

Outcome Variable: Smoking

A question on smoking— "do you smoke cigarettes or any other tobacco product"—was asked at each wave. In wave 1 (2001), the possible responses were "smokes," "has never smoked," and "has given up smoking." Here, we classified people into current smokers or as not currently smoking. In waves 2, 20 (2002–2020) possible responses were "no, I have never smoked," "no, I no longer smoke," "yes, I smoke daily,"

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"yes, I smoke at least weekly" and "yes, I smoke less often than weekly." People who responded that they were current smokers, no matter the frequency, were deemed to be smokers and ex and never smokers are deemed to be nonsmokers.

Main Inequality Group: Disability

For the main analysis, we classify respondents into two groups—people with a disability and people without a disability. The question, asked at every wave, to identify whether an individual has a disability is: "Do you have any long-term health condition, impairment, or disability that restricts you in your everyday activities, and has lasted or is likely to last, for six months or more?." To help, all respondents were shown showcards as prompts. On the showcards were listed specific examples of physical, sensory, psychological, and intellectual impairments and functional limitations. We use the responses to these items to place people into five disability subgroups for aim 1: sensory; physical; psychological; intellectual; physical disability and acquired brain injury; and "other" disabilities. These are based on the disability groupings used in Australia's main source of data on disability prevalence—the Survey of Disability Ageing and Carers (SDAC)—which is aligned with the International Classification of Functioning (ICF), the World Health Organisation framework for measuring health and disability.[14] For aim two, due to further disaggregation by income tertile, we combined two of the five subgroups, leaving three disability subgroups (cognitive disability (psychological and intellectual disability); other and sensory disability; physical disability and acquired brain injury). For further details on the concepts underpinning the disability question in HILDA, and a description of the responses to items on the showcards, please see sections 1.1–1.3 in the eAppendix; http://links.lww.com/EDE/C2.

Inequality Subgroup: Income

We calculated equivalized household income in each year by summing the income for each of the adults in the household and then equivalized using the modified OECD scale.[26] We calculated these tertiles for the whole HILDA sample and individuals were then placed into one of three tertiles in each year.

Smoking Prevalence Estimation

Confounding by Age

Age is related to disability and smoking. To adjust for this confounding effect we directly age-standardize people with and without disabilities to the 2011 Australian standard population published by the Australian Bureau of Statistics.[27]

Model Predicted Trends in Smoking Prevalence

For research aim 1, we fit a model with trends for people with and without disability separately (i.e., two trends). For research aim 2, we fit a model with separate trends for people with and without disability within each income tertile (i.e., six trends).

To estimate the linear time trends of smoking prevalence for research aims 1 and 2, we fit a Bayesian hierarchical model to binomial proportions. For aim 1, we estimate two trends in smoking prevalence (for people with and without disability, respectively) that are assumed to be linear on the logit scale. For each of these trends, we assume that prevalence counts y_{it} (within each strata of interest [i.e., people with and without disability] $i = 1, \ldots, I$ at time point t) come from a binomial distribution:

$$y_{it} \sim \text{binomial}\left(k_{it}, \varphi_{it}\right). \tag{1}$$

The denominator population for each group and time-point combination is represented by k_{it}. The model for φ_{it}, the estimate of group-specific prevalence at time t, is:

$$\log\left(\frac{\varphi_{it}}{1-\varphi_{it}}\right) = \beta_{i\,0} + \beta_{i\,1}\, t, \tag{2}$$

where $\beta_{i\,0}$ and $\beta_{i\,1}$ denote group-specific intercept and slope parameter, respectively. The population parameter for prevalence φ_{it} in group i at time t is assumed to be linearly related to time on the logit scale.

We specify the following priors for the regression coefficients $\beta_{i\,0}$ and $\beta_{i\,1}$:

$$\begin{aligned} \beta_{\,0} &\sim N(0,\ 1) \\ \beta_{\,1} &\sim N(0,\ 1) \end{aligned} \tag{3}$$

The priors for the coefficients are easily overwhelmed by data and are often used in similar hierarchical models.[28]

For aim 2, we fit the same model but to six smoking prevalence time trends: people with and without disability within each income tertile.

We fit models using the probabilistic programming language Stan.[29]

Calculating Absolute and Relative (Shortfall) Inequalities

To calculate inequalities, we compare model estimates of smoking prevalence for people with disabilities, to those without in the whole population (research aim 1) and then within each income strata (research aim 2). Prevalence ratios (relative [shortfall] inequalities) and prevalence differences (absolute inequalities) are calculated in the standard way, making use of the whole posterior distribution to estimate uncertainty.

Inequality Plots

To obtain a comprehensive picture of the trend over time in smoking prevalence and inequalities, one needs to consider both absolute and relative inequalities, alongside smoking prevalence for people with or without disabilities. The prevalence of smoking among people without (or with) disabilities is mathematically related to both the prevalence difference and

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prevalence ratio. Consequently, all three quantities of interest can be displayed simultaneously on the same plot.[22]

We applied a visualization technique where the prevalence of smoking for a given reference group is plotted on the *x* axis and the prevalence difference (our measure of absolute inequality) on the *y* axis. The prevalence ratio (our measure of relative, shortfall inequality) is represented by a series of contour lines.

To obtain a representation of uncertainty, we plot the whole joint-posterior probability distribution for the predicted smoking prevalence and inequalities of interest for each year. To help guide the reader, the solid black lines represent the median estimated values, the dashed lines represent the 2.5th and 97.5th percentiles, respectively, and the arrow represents the direction of the trend over time.

Calculating and Summarizing Change in Prevalence and Inequalities

To further aid interpretation of the plots and to classify the trends of smoking prevalence, prevalence differences, and prevalence ratios (shortfall), we use an inequality typology. The inequality typology has three components: smoking prevalence (labeled *p*), absolute inequalities (labeled *a*), and relative inequalities (labeled *r*). We assess each of these components qualitatively as declining (↓), increasing (↑), or stable (-).

To determine the direction of the trend, we compute the contrast of smoking prevalence (for people with and without disability), the prevalence difference and prevalence ratio between 2020 and 2001 for each iteration of the model fit. We use the contrast from each model iteration to provide a posterior distribution for each of these three components. This is then used to obtain an estimate of uncertainty of trends in prevalence and inequalities.

From a public health point of view, focused on both improving overall health and reducing health disparities, falling trends in smoking prevalence and relative and absolute inequalities are desirable; this would be classified as $p\downarrow, a\downarrow, r\downarrow$.

Regarding the trend on the inequality plot, the trend line would head leftward in respect of the *x* axis (falling smoking prevalence for people without disabilities), head downward in respect of the *y* axis (reduction in the prevalence difference for people with disabilities in comparison to those without) and crossing rate ratio contours (falling rate ratio). In this circumstance, the trend would be moving toward the bottom left-hand quadrant of the inequality plot.

Examples of how combinations of different smoking prevalence trends for people with and without disability translate to the inequality typology plots detailed above are given in section 1.4 of the eAppendix; http://links.lww.com/EDE/C2.

RESULTS

Description of Sample

Table 1 compares the unweighted age, gender, income, and smoking profiles for the sample in 2001 and 2020. The age distribution for people with and without disability was similar in both 2001 and 2020. In both waves people with disability were more likely to be in the lowest income tertile than people without disability. This income gradient is particularly evident in the "intellectual" and "psychological" disability subgroups (see eTable 2; http://links.lww.com/EDE/C2).

While unadjusted smoking prevalence decreased, it remained higher for people with disability, compared with people without, at both the start and the end of the study.

Smoking Prevalence and Inequalities Comparing People With and Without Disability

Figure 1A details the survey-weighted age standardized smoking prevalence for people with and without disability from 2001 to 2020. Predicted prevalence for the first and last year of the study is detailed in eTable 3 in section 1.5 of the eAppendix http://links.lww.com/EDE/C2. Over the whole study period, after age-standardization, smoking prevalence is higher for people with disability than people without disability. Prevalence is, though, falling for both groups over the 20 years of the study: −13 (−16, −11) per 100 people with a disability and −15 (−16, −14) per 100 people without disability. However, the absolute gap between the two groups does not appear to be closing.

Table 2 details the absolute change over 20 years in smoking prevalence (per 100 people) for people with and without disability, the change in prevalence difference (per 100 people), and the change in prevalence ratios. The change in prevalence ratio is hard to interpret. We include it, and its estimate of precision, to assess change in relative inequalities. Our inequality plot, Figure 1B, summarizes these predicted changes, taken from our model, of smoking prevalence for people without disability (*x* axis), absolute inequalities (i.e., prevalence difference, *y* axis) and relative inequalities (i.e., prevalence ratio, contour lines).

The trend lines traveling leftward relative to the *x* axis shows the decline in smoking prevalence among people without disability (model predicted change of −15 per 100 people [−16, −14]). However, with the trend almost perpendicular in respect of the *y* axis and crossing contour lines the absolute inequality is stable and relative inequality is increasing, resulting in an inequality typology of "$p\downarrow$ *a*- $r\uparrow$."

These findings—persistent inequalities—were consistent across the five disability subgroups (intellectual disability; other disability; physical disability and acquired brain injury; psychological disability; and sensory disability) we constructed from responses to the showcard information (see section 1.6 of the eAppendix; http://links.lww.com/EDE/C2).

Smoking Prevalence and Inequalities Comparing People With and Without Disability Within Income Tertiles

Figure 2A details age-standardized smoking prevalence for people with and without disability within income tertiles from 2001 to 2020. Overall, smoking prevalence is higher in

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TABLE 1. Unadjusted Description of the Analytic Sample and First and Last Waves of the Study

	2001		2020	
	With Disability	**Without Disability**	**With Disability**	**Without Disability**
Total	1,021	6,241	1,370	6,229
Smokes	399 (39%)	1,750 (28%)	386 (28%)	985 (16%)
Income tertiles				
Lowest income	379 (37%)	1,500 (24%)	534 (39%)	1,429 (23%)
Middle income	367 (36%)	2,432 (39%)	500 (36%)	2,388 (38%)
Highest income	275 (27%)	2,309 (37%)	336 (25%)	2,412 (39%)
Age, y				
15–19	121 (12%)	1023 (16%)	191 (14%)	823 (13%)
20–24	115 (11%)	800 (13%)	224 (16%)	980 (16%)
25–29	142 (14%)	955 (15%)	271 (20%)	1,224 (20%)
30–34	186 (18%)	1,120 (18%)	268 (20%)	1,215 (20%)
35–39	230 (23%)	1,203 (19%)	210 (15%)	1,115 (18%)
40–44	227 (22%)	1,140 (18%)	206 (15%)	872 (14%)

Data from the Household Income and Labour Dynamics in Australia survey.

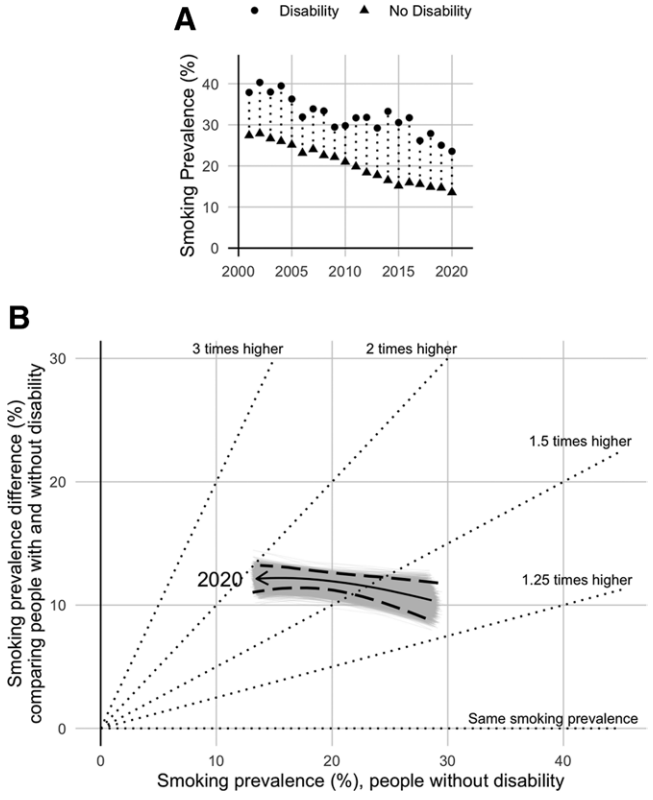


FIGURE 1. Trends in smoking prevalence and inequalities by disability. A, Age standardized smoking prevalence over time (2001–2020) comparing people with and without disability. B, Inequality typology plot, showing estimated smoking prevalence for people without disability (*x* axis), prevalence difference comparing people with and without disability (*y* axis) and prevalence ratio (contour lines, where all *x*-*y* coordinates on a given contour line have the same prevalence ratio). The dark trend line with an arrowhead is the mean posterior estimate of the time trend, labeled 2020 to denote the end of the time series; dashed trend lines denote the 95% credible interval of the time trend.

the low-income groups than in the middle- and high-income groups. For all three income groups, people with disability have higher smoking prevalence than people without disability; however, prevalence is falling across the board.

Declining smoking prevalence for people without disability evident in Figure 2A results in the trend lines for all three income tertiles moving from right to left on the inequality plot (Figure 2B). The model predicted change in smoking prevalence per 100 people without disability is similar across income groups (Table 2): −14 (−15, −12) for the low-income group, −16 (−17, −14) for the middle-income group, and −15 (−16, −14) for the high-income group. These changes in smoking prevalence results in three trend lines shifting approximately the same amount to the left.

Figure 2A shows absolute inequalities in smoking prevalence (the gap between the prevalence points), between people with and without disability, potentially widening in the low- and middle-income groups. This is confirmed on the inequality plot, as the trend lines move upward (in respect of the *y* axis). The change in prevalence difference is 4 (0, 8) per 100 people for the low-income group.

Relative inequalities are also increasing in both the low- and middle-income groups, as the trend lines move across contour lines (Figure 2B). This increase, alongside decreasing prevalence but increasing absolute inequalities results in an inequality typology of "$p\downarrow\ a\uparrow\ r\uparrow$" for both the low- and middle-income groups.

Figure 2A shows that inequalities between people with and without disability may be closing in the high-income group. This is also reflected on the inequality plot (Figure 2B) with the trend line moving down in respect of the *y* axis (falling absolute inequality) and tracking along the "1.25 times higher" relative inequality contour line. These trends result in an inequality typology of "$p\downarrow\ a\downarrow\ r$-" for the high-income group.

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TABLE 2. Model Estimated Change in Smoking Prevalence for People With and Without Disability (per 100 People), Change in Prevalence Difference (per 100 People), Change in Prevalence Ratio and Corresponding Inequality Typology

	Change in Prevalence (per 100 People), People With Disability	Change in Prevalence (per 100 People), People Without Disability	Change in Prevalence Difference (per 100 People)	Change in Prevalence Ratio	Typology
Total	−13 (−16, −11)	−15 (−16, −.14)	2 (−1, 4.0)	1 (0, 1)	p↓ a- r↑
Lowest income	−10 (−14, −6)	−14 (−15, −12)	4 (0, 8)	0 (0, 1)	p↓ a↑ r↑
Middle income	−13 (−16, −10)	−16 (−17, −14)	3 (−1, 6)	1 (0, 1)	p↓ a↑ r↑
Highest income	−21 (−25, −18)	−15 (−16, −14)	−6 (−10, −3)	0 (0, 0)	p↓ a↓ r-

Estimates taken from the posterior mean and 0.25th and 97.5th quantiles to obtain credible interval.

In the typology column there are the following three components: "p" denotes smoking prevalence for people without disability, "a" denotes absolute inequality (measured by prevalence difference), and "r" denotes relative inequality (measured by prevalence ratio. To indicate how each of the three components are changing over time "-" denotes stable, "↓" denotes falling, and "↑" denotes increasing.

It is worth noting that while absolute inequalities started off greater in the low- and middle-income groups, relative inequalities were, in fact, broadly similar (starting near the "1.25 times higher" contour). In the context of falling prevalence and potentially widening absolute inequalities for the low- and middle-income groups, this is no longer the case.

These findings—wider and persistent inequalities in low- and middle-income groups—are consistent across the three disability subgroups (cognitive disability (psychological and intellectual disability); other and sensory disability; physical disability and acquired brain injury) we were able to assemble for this part of the analysis (see section 1.7 of the eAppendix; http://links.lww.com/EDE/C2).

DISCUSSION

We used annual data from 2001 to 2020 of the Household Income and Labour Dynamics in Australia survey to estimate smoking prevalence trends and inequalities for people with and without disability, and whether these prevalence and inequality trends differ within income groups. Our data and model estimates show persistent inequalities in smoking prevalence for people with disabilities in comparison to those without, with evidence of increasing inequalities in low- and middle-income groups. When considering just disability (aim 1), there is strong evidence that inequalities are increasing on the relative scale and are probably stable on the absolute scale.

Our study confirms that low-income groups have higher smoking prevalence than high-income groups. We also find that disability-related inequalities vary across income strata—they are larger for people in low- and middle-income households, and could in fact be increasing on the absolute scale and are probably increasing on the relative scale (aim 2). This finding—substantive disability-related inequalities after stratifying by income—is consistent with previous literature that found higher smoking prevalence among people with disability after adjusting for socioeconomic status.[30]

However, this is not the case for people with disability in high-income households, where there are falling absolute inequalities and stable relative inequalities. In the context of overall falling prevalence, this is close to the most desirable change from a public health standpoint, which aims to reduce prevalence and close inequality gaps. That said, given that in our sample people with disability are less likely to have a high income (see Table 1), this would have little effect on disability-related inequalities if one was to average over income strata (effectively controlling for income)."

A strength of this study is that we use novel visualization techniques and hierarchical models with credible intervals that (a) help us make multiple complex comparisons of trends in prevalence and absolute and relative inequalities simultaneously and (b) display and summarize the uncertainty associated with these trends. These strengths allow us to make statements about how certain we are when assessing if smoking prevalence and inequalities have changed over time.

One potential limitation of the study is the definition and survey instrument used to capture disability. There is only one broad question in HILDA—"Do you have any long-term health condition, impairment, or disability that restricts you in your everyday activities, and has lasted or is likely to last, for six months or more?"—which uses a series of showcards to respondents to self-identify as having a disability. While we use the responses to the showcard information to assign people in our sample to broad disability groups that align with other sources of disability data in Australia, HILDA data do not capture detailed information on disability severity, functioning, or participation restrictions. Understanding the population of people with disability in more detail could help us better understand what facets of disability could be leading to higher levels of smoking. For example, our descriptive results show a clear social gradient among people with disability, in particular among people with intellectual and psychological disabilities. Furthermore, HILDA, as mentioned in the methods, does not cover the whole population of people with disability as it does not sample people with disability who live in communal settings.

A further limitation could be the self-reported smoking variables. However, there is good evidence that there is little misclassification of self-reported smoking.[31] We have

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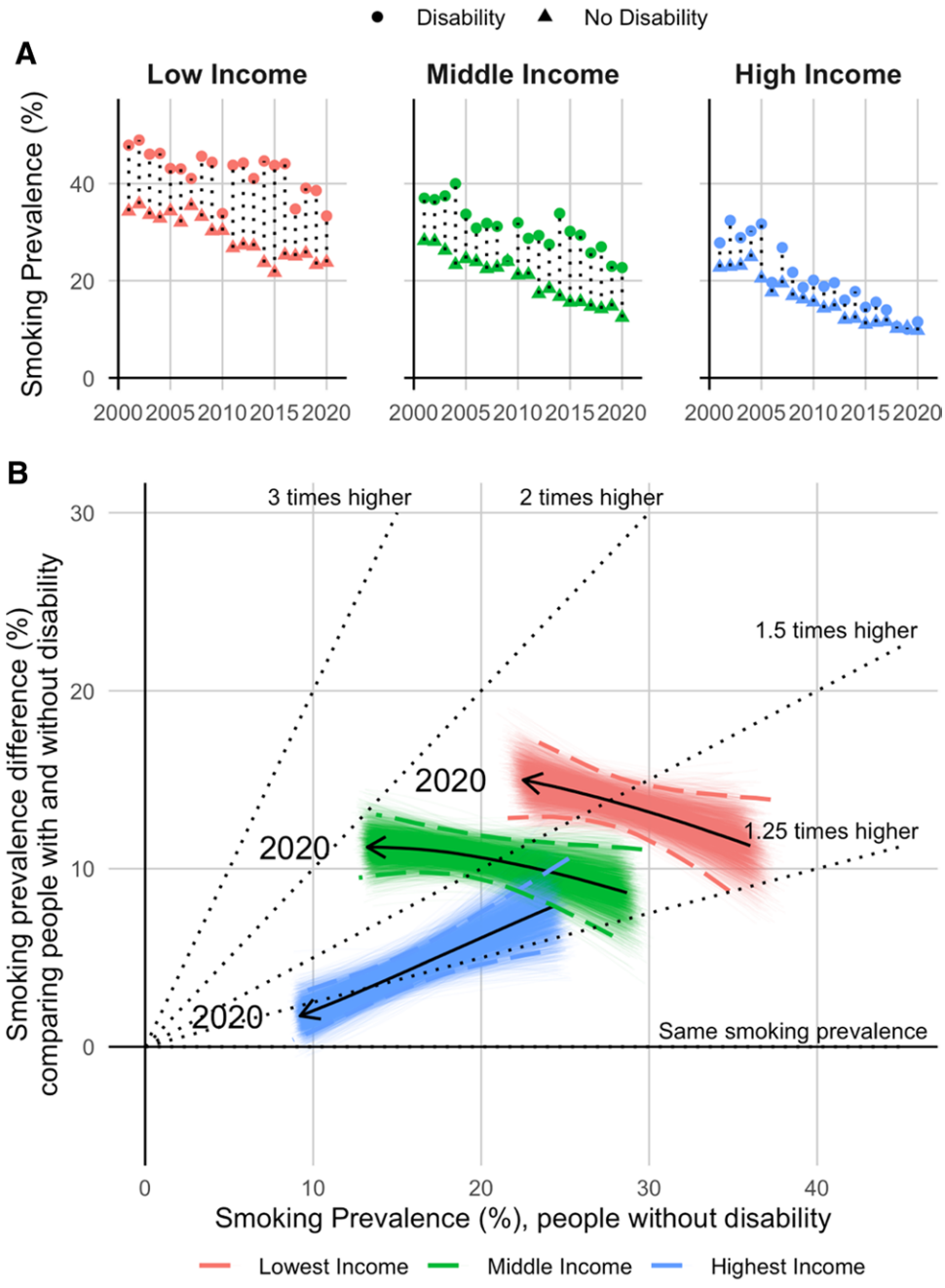


FIGURE 2. Trends in smoking prevalence and inequalities by disability and income tertile. A, Age standardized smoking prevalence over time (2001–2020) comparing people with and without disability within each income tertile. B, Inequality typology plot, comparing smoking prevalence for people without disability (*x* axis), absolute (*y* axis) and relative inequalities (contour lines) within each income tertile.

previously modeled the impact of misclassification on inequalities in smoking prevalence, in a different setting, and found that potential misclassification made little material change to results.[11]

A further limitation is that, for some individuals, smoking could be a cause of the self-reported disability status we use in this data. We have restricted to individuals aged between 15 and 44 years to guard against this, but results in this article should not be interpreted causally.

Having established that disability-related inequalities in smoking prevalence are persistent or worsening, more research is needed on differential uptake and cessation of smoking in disabled and nondisabled populations. As such, future research on disability-related inequality trends should make use of longitudinal data to establish the extent to which inequalities are driven by differential uptake and/or cessation.

We argue that health policy should have the dual goal of improving average health and reducing inequalities. This study covers a period where tobacco taxes have increased in Australia in 2010 followed by annual increases from 2013.[5] Given the effectiveness of tobacco taxes in putting downward pressure on smoking prevalence,[32] it is plausible that

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reductions in smoking prevalence among people with disability can be attributed to tobacco tax. However, previous research has shown that, apart from tobacco tax increases, tobacco control policies tend to be least effective among disadvantaged groups.[33] For people with disability, the danger is that, while policies may be successful in bringing down overall prevalence, people with disabilities, especially socioeconomically disadvantaged people with disability, get left behind if tax increases are not combined with adaptation of interventions specifically for people with disability.

As mentioned in the introduction, there is to our knowledge very little research on the effectiveness of smoking cessation programs tailored for people with disabilities. While there is an extensive literature on smoking cessation interventions among people with mental illness,[15] future research is needed on how cessation programs can be appropriately tailored to the specific needs of different groups of people with disabilities and how they can be prevented from initiating smoking in the first place.

REFERENCES

1. Marmot M, Allen J, Bell R, Bloomer E, Goldblatt P. WHO European review of social determinants of health and the health divide. *Lancet*. 2012;380:1011–1029.
2. Johnson KC. *Just One Cigarette a Day Seriously Elevates Cardiovascular Risk*. British Medical Journal Publishing Group; 2018.
3. World Health Organization WHO global report on mortality attributable to tobacco. 2012 https://apps.who.int/iris/bitstream/handle/10665/44815/9789241564434_eng.pdf. Accessed 20 December 2022.
4. Chaloupka FJ, Straif K, Leon ME; Working Group, International Agency for Research on Cancer. Effectiveness of tax and price policies in tobacco control. *Tob Control*. 2011;20:235–238.
5. Wilkinson AL, Scollo MM, Wakefield MA, Spittal MJ, Chaloupka FJ, Durkin SJ. Smoking prevalence following tobacco tax increases in Australia between 2001 and 2017: an interrupted time-series analysis. *Lancet Public Health*. 2019;4:e618–e627.
6. Blakely T, Gartner C. Tobacco taxes have mixed effects on socioeconomic disparities. *Lancet Public Health*. 2019;4:e595–e596.
7. Gregoraci G, Van Lenthe FJ, Artnik B, et al; DEMETRIQ consortium. Contribution of smoking to socioeconomic inequalities in mortality: a study of 14 European countries, 1990–2004. *Tob Control*. 2017;26:260–268.
8. Huijts T, Gkiouleka A, Reibling N, Thomson KH, Eikemo TA, Bambra C. Educational inequalities in risky health behaviours in 21 European countries: findings from the European Social Survey (2014) special module on the social determinants of health. *Eur J Public Health*. 2017;27(suppl_1):63–72.
9. Barbeau EM, Krieger N, Soobader M-J. Working class matters: socioeconomic disadvantage, race/ethnicity, gender, and smoking in NHIS 2000. *Am J Public Health*. 2004;94:269–278.
10. Health AIo, Welfare. People with disability in Australia 2020. 2020. https://www.aihw.gov.au/getmedia/ee5ee3c2-152d-4b5f-9901-71d483b47f03/aihw-dis-72.pdf.aspx. Accessed 20 December 2022.
11. Disney G, Gurrin L, Aitken Z, et al. Hierarchical models for international comparisons: smoking, disability, and social inequality in 21 European countries. *Epidemiology*. 2020;31:282–289.
12. Havercamp SM, Scott HM. National health surveillance of adults with disabilities, adults with intellectual and developmental disabilities, and adults with no disabilities. *Disabil Health J*. 2015;8:165–172.
13. Hall AG, Schumacher JR, Cannell MB, Berry JB, Schiaffino M, Park S. Tobacco use in Florida: Comparisons between adults living with and without disabilities. *Disabil Health J*. 2013;6:213–219.
14. WHO. *Towards a Common Language for Functioning*. Disability and Health (ICF): World Health Organisation; 2002.
15. Prochaska JJ, Das S, Young-Wolff KC. Smoking, mental illness, and public health. *Annu Rev Public Health*. 2017;38:165–185.
16. van Duijvenbode N, VanDerNagel JE. A systematic review of substance use (disorder) in individuals with mild to borderline intellectual disability. *Eur Addict Res*. 2019;25:263–282.
17. Kerr S, Lawrence M, Darbyshire C, Middleton A, Fitzsimmons L. Tobacco and alcohol-related interventions for people with mild/moderate intellectual disabilities: a systematic review of the literature. *J Intellect Disabil Res*. 2013;57:393–408.
18. Emerson E, Madden R, Graham H, Llewellyn G, Hatton C, Robertson J. The health of disabled people and the social determinants of health. *Public Health*. 2011;125:145–147.
19. Milner A, Krnjacki L, Butterworth P, Kavanagh A, LaMontagne AD. Does disability status modify the association between psychosocial job quality and mental health? A longitudinal fixed-effects analysis. *Soc Sci Med*. 2015;144:104–111.
20. Shields M, Dimov S, King TL, et al. Does disability modify the relationship between labour force status and psychological distress among young people? *Occup Environ Med*. 2020;78:438–444.
21. Kjellsson G, Gerdtham U-G, Petrie D. Lies, damned lies, and health inequality measurements: understanding the value judgments. *Epidemiology (Cambridge, Mass)*. 2015;26:673.
22. Blakely T, Disney G, Atkinson J, Teng A, Mackenbach JP. A typology for charting socioeconomic mortality gradients: "Go Southwest." *Epidemiology*. 2017;28:594–603.
23. Kjellsson G, Petrie D. Graphical tools for monitoring inequality: the beauty can lie (in the details). *Epidemiology*. 2017;28:604–607.
24. Watson N. Finding your way around the HILDA survey data. *Australian Econ Rev*. 2021;54:554–564.
25. Health AIo, Welfare. *Burden of Tobacco Use in Australia: Australian Burden of Disease Study 2015*. AIHW Canberra; 2019.
26. Hagenaars AJ, De Vos K, Asghar Zaidi M. Poverty statistics in the late 1980s: Research based on micro-data. 1994.
27. Statistics ABo. *Feature Article: Which Population to Use for Age Standardisation?* 2013. https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/3101.0Feature+Article1Mar%202013#:~:text=The%20ABS%20and%20AIHW%20recommend%20that%20the%2030%20June%202001,available%20after%20the%202026%20Census. Accessed 20 December 2022.
28. McElreath R. *Statistical Rethinking: A Bayesian Course with Examples in R and Stan*. Chapman and Hall/CRC; 2020.
29. Manual S. Stan modeling language users guide and reference manual, version 2.17. 0. 2017. https://usermanual.wiki/Document/STAN20User20Manualversion202170.685442313/view. Accessed 20 December 2022.
30. Courtney-Long E, Stevens A, Caraballo R, Ramon I, Armour BS. Disparities in current cigarette smoking prevalence by type of disability, 2009–2011. *Public Health Rep*. 2014;129:252–260.
31. Rebagliato M. *Validation of self reported smoking*. BMJ Publishing Group Ltd; 2002: 163–164.
32. Chaloupka FJ, Yurekli A, Fong GT. Tobacco taxes as a tobacco control strategy. *Tob Control*. 2012;21:172–180.
33. Hiscock R, Bauld L, Amos A, Fidler JA, Munafò M. Socioeconomic status and smoking: a review. *Ann N Y Acad Sci*. 2012;1248:107–123.

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