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Trends in cannabis use intention around the period of cannabis legalisation in Australia: An age-period-cohort model

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Abstract

Introduction: This study examines age, time period and birth cohort trends in cannabis use intention and weekly use in Australia over a period in which medicinal cannabis was legalised.

Methods: Hierarchical age-period-cohort models were used to analyse the National Drug Strategy Household Survey between 2001 and 2019, including 158,395 participants aged 18–79 years.

Results: The hierarchical age-period-cohort model demonstrated a decrease in likelihood of intending to try cannabis as age increases. Similar age effects were found in intending to use cannabis as often or less often. There was broad-based shift in attitudes for people wanting to try cannabis (2007: $b = -0.51$ [−0.82, −0.21]; 2019: $b = 0.68$ [0.38, 0.98]) or use cannabis more often (2007: b = −0.15 [−0.50, 0.20]; 2019: $b = 0.83$ [0.49, 1.18]). The population trend of weekly cannabis use decreased in the earlier periods but increased since 2013 ($b = -0.13$ [−0.25, −0.02] vs 2019: b = 0.06 [−0.09, 0.20]). This suggests that legalisation would increase uptake of cannabis and consumption among current consumers. There were distinctive inter-generation variations: people born between 1950s and 1960s had more liberal views towards cannabis use than people born before or after ($p < 0.05$). There were indications that young people born in the 1990 s are catching up with the baby boomers in using cannabis more often if it was legal.

Discussion and Conclusions: There has been a population-based shift in Australia in favourable attitudes towards cannabis use, more so among those born in the 1950s to 1960s than other generations. Liberal attitudes and more frequent cannabis use may put certain cohorts at higher risks of cannabis dependence and related harms.

KEYWORDS
age-period-cohort, cannabis, intention, marijuana, trend

1 | INTRODUCTION

Global support for cannabis legalisation has been rising, with more countries expanding public access to cannabis for medicinal and recreational uses in recent years [1–4]. A recent study reported a rapid rise in support for cannabis legalisation in Australia between 2007 and 2016, which was accompanied by birth-cohort specific changes in past-year cannabis use [4]. Older cohorts born in the 1950s–1960s were more likely to support legalisation and more likely to have used cannabis in the past year than others, indicating mid-life increases in use. These observations are consistent with the historical counter-culture movement of cannabis use in the 1960s–1970s across western countries, coinciding with the cohort's transition into young adulthood [4]. This suggests societal influence may have a long-term impact on individual's beliefs and perceptions [5].

In October 2016, Australia introduced a major cannabis policy reform to enable access to medicinal cannabis across the country, enabling cannabis-based products to be prescribed to eligible patients for a range of health conditions by registered healthcare professionals [6]. By June 2022, nearly 300,000 official approvals have been issued for access to more than 100 types of medicinal cannabis products to eligible patients [7]. This is in addition to the existing medicinal cannabis users who continue to purchase cannabis via illicit sources [7]. On 31 January 2020, the Australia Capital Territory (ACT) became the first Australian jurisdiction to decriminalise the possession, use and cultivation of small amounts of cannabis for adults [8]. Public health researchers have consistently expressed concerns about the additive effects of attitudinal change and medicinal cannabis legalisation would encourage cannabis use and increase the associated harms in the general population [4, 9].

Recent studies suggest medical cannabis legalisation has increased tolerant opinions about cannabis use [10]. A potential pathway in which legalisation affects cannabis use perceptions (e.g., reducing risk perception, accepting cannabis use and increasing use intention) may involve increasing availability of cannabis, which in its own way may normalise cannabis use [11, 12]. A US study comparing states with medical cannabis laws and those without have found that between 2004 and 2013, adults aged 26 years and above perceived that cannabis has become more readily available after the enactment of medical cannabis laws [11]. By 2014, more than half of all 12th graders believed that using cannabis weekly would cause no or little harm. Among US adults, the prevalence of perceived risk in using cannabis has dropped from 50.5% to 33.3% between 2002 and 2014 [13].

Some early evidence in the US suggests adults over the age of 26 who reside in states with medical cannabis laws were more likely to have used cannabis in the past year and past month than adults who reside in states that do not allow medicinal cannabis [14, 15]. Similar increases have been reported in Canada among adults over the age of 25 years after adult cannabis use was legalised in October 2018 [16]. Although there is limited evidence of an association between medical cannabis legalisation and cannabis use among young people (aged 12–20 years), it is associated with youth initiation of cannabis use and the number of days of cannabis use in young people [10].

This study examines the age, time period and birth cohort trends in cannabis use intention and weekly cannabis use among Australians from 2001 to 2019 which covers the critical period of the 2016 medicinal cannabis policy reforms in the country (before ACT's 2019 cannabis policy reform). Our study builds on previous work conducted by Kaur and colleagues [4] who analysed public opinion about cannabis legalisation, criminalisation and past-year use. We built onto this by examining public changes in cannabis use intention and weekly cannabis use. These outcomes were chosen because (i) access to medicinal cannabis remains limited and non-medicinal cannabis is illegal in Australia, therefore, cannabis use intention would be a good indicator for future cannabis use when it became legal; and (ii) consumers who use cannabis use frequently contributed to most cannabis consumption in Australia [17] and they would be most affected by legalisation.

2 | METHODS

2.1 | Data source

The study utilised the cross-sectional National Drug Strategy Household Survey (NDSHS) series. The NDSHS has been conducted triennially to collect information about public attitudes and behaviour in relation to licit and illicit substance use among persons aged 14 and above since 1998. The present study included seven waves of the survey conducted between 2001 and 2019.

2.2 | Ethics

The access of the NDSHS data has been approved by the Australian Data Archive on behalf of the Australian Institute of Health and Welfare. The data contains non-identifiable data of survey respondents. The study has been reviewed by The University of Queensland Human

Research Ethics Committee and approval for ethics exemption was granted (#2019001159).

2.3 | Sampling design and study population

The nationally representative NDSHS sample were selected using stratified, multistage random sampling of household within each geographical stratum. Details of sampling method is described elsewhere [18]. Data collection methodologies are documented in Table S1, Supporting Information. Response rate ranged from 46% to 51.1% (2001: 50%; 2004: 46%; 2007: 49.3%; 2010: 50.5%; 2013: 49.1%; 2016: 51.1%; 2019: 49.0%), which included 23,356 to 29,445 respondents in each wave of the survey (Note: The 2019 data collection period occurred before the ACT's recent cannabis policy reform). While the response rate is similar to other national surveys collecting sensitive information [19], statistical weight was applied to adjust for any underrepresentation of population subgroups (household size, age and sex) in an effort to reduce non-response bias.

2.4 | Outcome measurements

Respondents' intention to use cannabis was assessed by answers to the question: "*If Marijuana/Cannabis were legal to use, would you…?*", with answers "*not use it, even if it were legal and available*", "*try it or use it about as often as I do now*", "*use it more often than I do now*", "*use it less often than I do now*" or "*do not know*". Those reporting "*not use it*" were compared across the other categories, while missing responses and responses of "*do not know*" were omitted.

Cannabis use patterns were assessed by self-reported frequency of use: "*In the last 12 months, how often did you use Marijuana/Cannabis?*" with possible answers "*every day*", "*once a week or more*", "*about once a month*", "*every few months*" or "*once or twice a year*". The responses were categorised into either: (i) weekly use or more often (those reported using "*every day*" or "*once a week or more*"); or (ii) use less than once a week (the remaining responses).

2.5 | Independent variables

The primary independent variables measured were age, time period (year of survey) and birth cohort (year of birth) memberships. In this study, the age effect represents the average change in cannabis-related attitudes as an individual age, regardless of their birth cohort or the time period in which they participated in the survey. The birth cohort effect represents the influence of being born in certain time period and sharing similar social experiences and historical events at similar ages through the life-course. Finally, the time period effect represents the variation in public attitudes at a particular time, affecting people across all ages and birth cohorts uniformly in the country.

Following conventional methodological guidelines [20], self-reported age (as a continuous variable) was coded in years, centred for the grand mean of age. The model considered the non-linear relationship of age and the outcome variables by fitting a quadratic function of age, (i.e., age-squared) as an independent variable in the models. Age was restricted to 18 to 79 years old, as the variable has been collapsed into a single category for those aged 80 years or older in the 2016 survey. The survey year represented the time periods (as a categorical variable; triannually between 2001 and 2019). Year of birth was derived by subtracting the self-reported age of each respondent from the survey year. As guided by previous study [4], birth years were categorised into thirteen 5-year birth cohort groups ranging between 1916 and 2001, except for those born from 1916 to 1939 and 1995 to 2001 who were included in the same group due to small sample sizes. Sensitivity analysis was conducted to assess the robustness of the results by omitting some earlier cohorts.

2.6 | Statistical analysis

We described the overall trends in cannabis use intention and weekly cannabis use across the time periods, and then by age and birth cohort.

The effects of age, time period and birth cohort on individual-level of cannabis use intention were analysed using the hierarchical age period cohort (HAPC) estimation with Cross-Classified Random Effects Modelling (CCREM) as proposed by Yang and Land [21]. This method has been applied to several other repeated cross-sectional national data sets in social and health studies [4, 22–24]. The mixed (fixed and random) effects model statistically characterises the contextual effects unique to the survey period and birth cohort memberships. The hierarchical model consists of two levels. The first level of the regression model takes account of the individual's age with an intercept term, fixed regression slope coefficients and an individual-level error term.

$$\text{logit}(\text{attitudes})_{ijk} = \beta_{ojk} + \beta_1 \text{AGE}_{ijk} + \beta_2 \text{AGE}^2{}_{ijk} + e_{ijk}$$

Individual *i*'s cannabis use intention and pattern of weekly cannabis use were modelled as a function of each

individuals' age, where i_{jk} represents individuals nested within birth cohort j and survey period k. β_{ojk} is the intercept (or "cell mean") for individuals in the respective birth cohort (j) and survey period (k). β_1 and β_2 are the individual-level fixed effects for each of the explanatory variables (i.e., age and age-squared), and e_{ijk} is the individual-level error term.

The second level of the model accounts for variability in the intercept and slope parameters between birth cohorts and survey periods (random effects).

$$\beta_{ojk} = \gamma_0 + u_{0j} + v_{0k}$$

It uses level 1 regression coefficients as outcomes and contains intercepts and specification of random effect coefficients for the effects of each birth cohort and survey period. The γ_0 in this equation represents the model intercept, which is the overall mean of the measured outcomes. The u_{0j} and v_{0k} are the residual random effects of birth cohort and survey period, respectively. The complete model is represented by the equation below.

$$\text{logit}(\text{attitudes})_{ijk} = \gamma_0 + \beta_1 \text{AGE}_{ijk} + \beta_2 \text{AGE}^2{}_{ijk} + u_{0j} + v_{0k} + e_{ijk}$$

Multinomial regression and binary regression models were applied to assess cannabis use intention and weekly cannabis use, respectively. All analyses were conducted using SAS software version 9.4. Median odds ratios were produced to estimate the median effect size of the random effects (i.e., period and birth cohort) that were specified in the models. When comparing individuals in the same age (fixed effect), the median odds ratios quantified the individual probability of cannabis use intention and weekly use outcomes determined by the contextual phenomena (i.e., whether they would change their attitudes and use behaviour if completing the survey in a different year or changing birth cohort memberships). It was derived from the covariance parameter generated from the HAPC model using the formulae from Merlo et al. [25]:

$$e^{\left(\sqrt{2} * \text{period level variance} * 0.6745\right)}$$

2.7 | Sensitivity analysis

The use of age-period-cohort analysis has been contentious due to the potential collinearity of age, period and cohort effects. It is important to clarify that the mixed-effects HAPC-CCREM does not suffer the same issue because the three effects are not assumed to be linear and additive at the same level of analysis. However, it has also been suggested that the estimates generated by HAPC-CCREM can be easily affected by the number and size of the age, period and cohort groupings. Based on the advice from Masters and Powers [26], additional analyses were conducted to ensure the validity and robustness of our results. First, the first birth cohort (1916–1939) contained a larger number of birth cohort compared with the rest of cohort groups. The large cohort group may have included cohort members who were heterogenous in terms of lifetime experiences. We validated our results by removing the participants who were born in the earlier years (1916–1929). Second, we applied a different interval range of each variable. by modelling the time period and birth cohort into 3- and 10-year intervals, respectively.

3 | RESULTS

3.1 | Sample characteristics

This study included 158,395 participants aged 18 to 79 years. Among the total population, 49.5% were male and the average age was 47.4 years (median = 47.0; SD = 16.4). The weighted prevalence of Australians' intention to try or use cannabis, and weekly cannabis use over time are documented in the Supporting Information (Table S1, Figures S1 and S2). The median odds ratios of period and birth cohort effects on each outcome are documented in Table 1.

3.2 | Changes in cannabis use intentions

The level 1 portion of the HAPC model demonstrated a decrease in likelihood of intending to try cannabis as people get older (age *b*: −0.041; 95% confidence interval [CI] −0.045, −0.037). The positive quadratic effect of age (age-squared *b*: 0.00045; 95% CI 0.00030, 0.00059) suggested that as people get older the effect of age became weaker. Similar age effects were found in self-reported intention to use cannabis as often or less often, except for the intention to use cannabis more often (age: *b*: −0.00037; 95% CI −0.00068, −0.00006; age-squared: *b*: −0.00037; 95% CI −0.00068, −0.00006).

The level 2 portion of the HAPC model demonstrated an increasing likelihood of intention to use cannabis between 2010 and 2019. The results of regression analysis are presented in Table S3, Supporting Information. Changes were relatively small in the intention to use cannabis as often (Figure 1c; *b* in 2010: −0.17, 95% CI −0.27, −0.06; *b* in 2019: 0.21, 95% CI 0.08, 0.34) or less (Figure 1g; *b* in 2010: −0.14, 95% CI −0.31, 0.04; *b* in

TABLE 1 Median odds ratio for the estimating period and birth cohort effects generated from hierarchical age-period-cohort (HAPC) models

Outcomes	Period effects				Birth cohort effects			
	Covariance parameter	Standard error	*p* value[a]	Median odds ratio	Covariance parameter	Standard error	*p* value[a]	Median odds ratio
Would try cannabis[b]	0.1589	0.09292	0.0437	1.757228	0.02273	0.01075	0.0173	1.237649
Would use cannabis as often[b]	0.01637	0.01028	0.0556	1.198346	0.5962	0.2716	0.0141	2.980141
Would use cannabis more often[b]	0.1937	0.1152	0.0463	1.863422	0.05201	0.03211	0.0526	1.380604
Would use cannabis less often[b]	0.0153	0.01597	0.1691	1.191161	0.05217	0.04135	0.1035	1.381289
Weekly use of cannabis[c]	0.01572	0.01047	0.0667	1.194005	1.3859	0.6267	0.0135	5.284999

[a]The *p* value should be interpreted cautiously due to small sample sizes of the cannabis use intention subgroups and weekly use of cannabis.
[b]The HAPC model used for assessing cannabis use intention was a multinomial regression model.
[c]The HAPC model used for assessing weekly use of cannabis was a binary regression model.

2019: 0.13, 95% CI −0.05, 0.31). A significant shift in attitudes was observed among people who would like to try cannabis (Figure 1a; *b* in 2010: −0.13, 95% CI −0.43, 0.17; *b* in 2019: 0.68, 0.38, 0.98) or use cannabis more often (Figure 1e; *b* in 2010: −0.25, 95% CI −0.60, 0.10; *b* in 2019: 0.83, 95% CI 0.49, 1.18).

There were distinctive inter-generation variations: people born during 1950s–1960s were more inclined to use cannabis than others who were born before or after. For intention to try cannabis or to use cannabis more often, people born after the mid-1980 s appeared catching up with the 50s–60s birth cohort (Figure 1b, f). Findings from the sensitivity analyses were consistent, supporting the robustness of our results (Supporting Information: Tables S4 and S5 and Figures S3 to S6).

3.3 | Changes in weekly cannabis use

The level 1 portion of the HAPC model demonstrated a decrease in likelihood of weekly cannabis use as people get older (age *b*: −0.0260; 95% CI −0.0374, −0.0146). The positive quadratic effect of age (age-squared *b*: 0.000614; 95% CI 0.000419, 0.000808), suggested that as people get older the effect of age becomes weaker.

The period trend of population using cannabis weekly or more often decreased in the earlier periods but experienced a significant increase in 2013 (Figure 2a). We observed increasing time period effect for the years 2016 to 2019 compared with the lowest point in 2013 (*b* in 2013: −0.13, 95% CI −0.25, −0.02; *b* in 2016: 0.01, 95% CI −0.12, 0.14; *b* in 2019: 0.06, 95% CI −0.09, 0.20). The HAPC analysis demonstrated significant inter-generation variations: participants born between 1950s and 1960s were more likely to have used cannabis weekly than those who were born in the cohorts before and after (Figure 2b). Results are documented in Table S6.

4 | DISCUSSION

In our analysis of NDSHS between 2001 and 2019 we found significant period effects on people's intention to try cannabis or use cannabis more often if it were legalised among Australian adults. Significant birth cohort variations were observed in all measures.

We observed larger increases in all cannabis use intentions among people born in the 1950s to 1960s than in those who were born before or after. As emerging adults, people in this generation experienced a decade in which the counterculture movement flourished from the mid-1960 s to mid-1970 s across many Western countries including Australia [4]. The social movement was marked by a revolution in social norms that were positive towards cannabis use. Living through this period appears to have influenced the attitudes about cannabis for this generation, making them more accepting of cannabis use than adults who were members of earlier or more recent birth cohorts. Although previous study suggests the likelihood of recent cannabis use is lower among the younger generations [4], there are signs that young people born in the 1990s to be catching up with the baby boomers in their intention to try or to use cannabis more often if it was legal. This appears consistent with a previous study

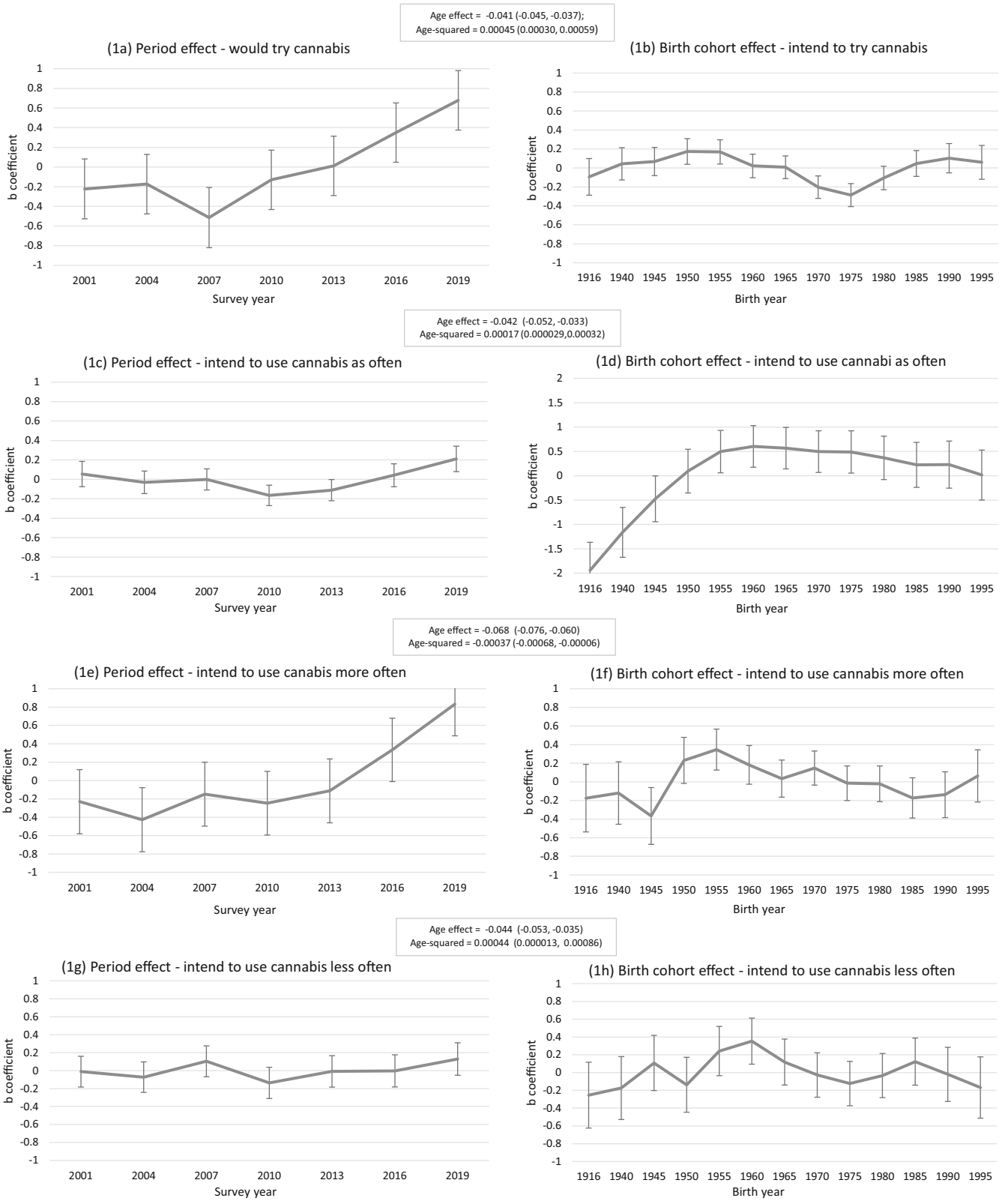

FIGURE 1 Hierarchical age-period-cohort estimates of period and birth cohort effects of cannabis use intentions after legalisation among adult participants in seven waves of the Australian National Drug Strategy Household Survey from 2001 to 2019.

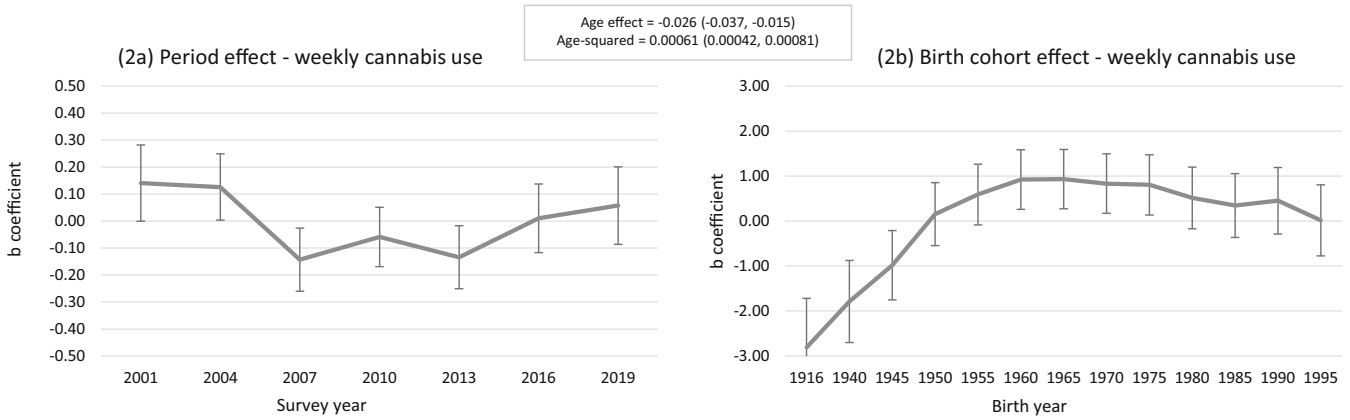

FIGURE 2 Hierarchical age-period-cohort estimates of period and cohort effects of weekly use of cannabis among adult participants in seven waves of the Australian National Drug Strategy Household Survey from 2001 to 2019.

that have found the association between medical cannabis legalisation and initiation of cannabis use and more frequent use among youths [10].

There was evidence of broad-based shift in cannabis use intention since 2010. Specifically, there were more people who had never used cannabis who expressed an interest in trying cannabis, and more cannabis users intended to use cannabis more often, if its use was legal. This, again, indicates a potential increased uptake of cannabis and increased consumption among the current cannabis consumers after legalisation.

We saw a shift in cannabis use intention beginning in 2007, 9 years before the implementation of the medicinal cannabis scheme in 2016. This could be due to various reasons. First, the increase in acceptance of cannabis uses and use intention may have been influenced by the cannabis liberalisation in the US over the study period. The access to medicinal cannabis was first legalised in California in 1996. In 2012, citizens of Colorado and Washington voted to legalise recreational cannabis use, generating a great deal of discourse in traditional and social media worldwide including Australia [27–29]. Positive media coverage of patients benefiting from medicinal cannabis and pro-legalisation discussions in social media challenged the previously dominant media coverage of cannabis as a dangerous drug.

Exposure to positive narratives on patients using medicinal cannabis have been found to increase positive attitudes and cannabis use intention in the general population, including non-users [30, 31]. The HAPC analysis demonstrated the time-varying trend to identify where changes began, instead of assuming that public attitudes changed sharply at a certain time point (i.e., 2016). Our analysis suggests that the growing support for medicinal cannabis may have convinced the government to approve access for patients (rather than the other way around) [32, 33]. Previous studies have shown that legalisation encouraged more frequent consumption among current consumers in the belief that regular use poses little harm [32, 33]. Further research is needed to understands the association between legalisation and cannabis consumption among current consumers.

4.1 | Policy implications

The increases in recent cannabis use among adults aged 25 years and older reported after legalisation in the US and Canada, suggest that there may be similar increases in use if Australia legalises cannabis in the future. What might Australia learn from the US cannabis legalisation framework? The attempts by some state governments in the US to reduce the size of cannabis black market through legalisation have lowered prices and improved accessibility of cannabis and increased the prevalence of regular use. In this study, we have observed a rapid growth in weekly cannabis use between 2013 and 2019. When cannabis use becomes fully legalised, a for-profit cannabis industry will have a commercial interest in expanding the number of daily consumers [34]. The profitability of the enormous cannabis markets will give the industry sufficient resources to resist public health regulations, which seems to be happening with the legal cannabis industry in the US [34, 35].

Cannabis policy does not have to be a binary option between prohibition and legalisation with commercialisation [36]. Policymakers can learn from some of their successes in alcohol and tobacco control by: imposing taxes based on cannabis potency to reduce dependence and harms from heavy use [37], limiting outlet trading hours and density [38], restricting marketing activities that target vulnerable consumer groups and plain packaging of cannabis products to discourage youth initiation [39].

4.2 | Limitations

This study covered a critical period when Australian experienced the 2016 medicinal cannabis policy reforms, a significant change in cannabis regulation in recent history. However, it is not without limitations. Our analyses did not assess correlations between the variables. The similar patterns in time period and birth cohort changes in cannabis use intention and weekly cannabis use could be co-occurring without indicating a causal relationship. Second, the collinearity among the variables cannot be completely eliminated. However, the aim of this study was not to estimate these effects but to observe the trend direction in the context of cannabis relaxation. Therefore, the identification problems would not cause a significant issue in our results. Third, while respondents were reminded that their participation to the survey will be anonymous, self-reported cannabis-related attitudes may still be under-reported. Finally, the NDSHS collects data from residential households, which excludes hospitals and nursing homes, non-permanent addresses. Nonetheless, any reporting bias would be consistent across the survey years, and our results should still provide good guidance on changing patterns of age, time period and birth cohort effects on the outcomes we measured.

5 | CONCLUSIONS

This study found strong evidence of shifts in the Australian population in attitudes towards cannabis legalisation and use intentions. These were accompanied by a small growth in the proportion of Australians who reported using cannabis weekly. More liberal attitudes were found among those born between 1950s and 1960s birth cohorts who were also more likely to have used cannabis frequently. This generation is unique in having had more experience with cannabis as young adults, and their perceptions about the low risks of cannabis use may put them at a higher risk of experiencing adverse health outcomes.

AUTHOR CONTRIBUTIONS

VC, JL and WH designed the study. VC, GC, JL and WH contributed to the methodology. VC organised the resources and conducted formal analysis. VC wrote the first draft of the manuscript and GC, JL, WH and LH provided supervision, contributed to and have approved the final manuscript.

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ETHICS STATEMENT

The authors declare that their contribution to this work meets the standards of the International Society of Addiction Journal Editors.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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