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DO 'ALL-AGE' BICYCLE HELMET LAWS WORK? EVIDENCE FROM CANADA

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ABSTRACT

Twenty-one states and the District of Columbia require youths to wear helmets when riding a bicycle, and there has been a push to extend such laws to adults. We provide new evidence on helmet laws by studying Canada using difference-in-differences models and restricted area-identified public health survey data with information on cycling and helmet use for nearly 800,000 individuals from 1994-2014. We first confirm prior patterns from the US that laws requiring youths to wear helmets significantly increased youth helmet use. We then provide the literature's first comprehensive evidence that 'all-age' bicycle helmet laws significantly increased both adult and youth helmet use by 50 to 190 percent relative to pre-reform levels, with larger effects for younger adults, and less-educated adults. All-age helmet laws had modest effects at reducing cycling and increasing in-home exercise during winter months among adults but did not meaningfully affect weight. Finally, we find larger effects of helmet laws at increasing helmet use for adults with children in the household, consistent with role-modeling behavior. Overall our findings confirm that all-age helmet laws can be effective at increasing population helmet use without significant unintended adverse health consequences.

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1. Introduction

Bicycling is enjoyed by over 66 million adults in the United States (Statista 2018) but is also associated with substantial health risks: according to the American Association of Neurological Surgeons, cycling is the sport that accounts for the largest number of head injuries for individuals seen in emergency rooms, nearly double the number of the next closest sporting activity (85,389 in 2009, compared to 46,948 for football) (AANS 2018). In response to medical evidence that properly worn bicycle helmets dramatically reduce the likelihood and severity of serious head trauma in bicycle accidents, governments have increasingly adopted laws requiring children to wear helmets when riding a bicycle. Previous quasi-experimental research using the staggered timing of adoption of mandatory youth helmet laws across US states has shown that these laws had robust effects at reducing bicycle-related deaths (Grant and Rutner 2004) and injuries (Chatterji and Markowitz 2015) among youths. Moreover, research shows that these policy-induced health improvements occurred not only through significantly greater helmet wearing by youths but also through significantly reduced youth bicycling participation (Carpenter and Stehr 2011).[1]

In part based on the evidence that youth bicycle helmet laws reduce fatalities, local and state governments in the US have debated extending helmet laws to apply to all individuals, including adults. These 'all-age' helmet laws have been met with strong opposition from cycling activists, and thus far these policies have not been adopted by any US state[2], though a handful of places outside the US have adopted them, including Australia and New Zealand. As public bike-

[1] This type of substitution has a long history in economics, beginning with Peltzman (1975).

[2] Foss and Bierness (2000) report that 20 communities in the United States have all-age helmet requirements. For example, Dallas, Texas has had such a policy since 1996. The Washington State Department of Transportation lists 20 cities and counties in the state that have all-age helmet laws, including Seattle, Spokane, and Tacoma (Washington does not have a state bicycle helmet law). State legislators considered all-age helmet laws in Maryland in 2013 (Halsey 2013) and in California in 2015 (San Francisco Chronicle 2015), but neither was adopted.

share programs proliferate across North America and Europe, there is growing concern that policies requiring adults to wear helmets would substantially limit their popularity and effectiveness (Fucoloro 2011).

Would all-age helmet laws affect adults differently than youths, and relatedly, would adults comply with requirements to wear helmets while cycling? There are many possible considerations. For example, we know from descriptive public health surveys that there are large differences in helmet use and cycling behaviors for children and adults even in places without any helmet legislation, so it is not obvious that helmet laws would affect these two groups similarly. Figure 1 makes this point explicitly by showing the age profile from our public health data (described in detail below) for each single year of age from 12 to 64; it shows clear differences across the life course in cycling and helmet use behaviors. Also, adults are more likely to have resources to be able to obtain helmets compared to youths. The strong social pressures against wearing helmets are also likely to be less salient for adults compared to children, and adults may also be more able than youths to comprehend the health risks from not wearing helmets. Adults are likely to have much more experience cycling than youths, however, and this may cause them to wear helmets less, reasoning that they are more able to avoid accidents due to their greater cycling skills. With respect to cycling behavior, children are likely to have fewer alternative transportation options available to them compared to adults (because of minimum driving ages), so we might expect helmet laws to depress cycling more among adults than children due to their greater ability to substitute. Finally, we are interested in whether helmet law effects on adults differ between those with children and those without children to test for possible role model effects in helmet wearing behavior and responsiveness to public health regulations.

We provide the first quasi-experimental evidence on the effects of 'all-age' helmet laws by examining Canada where four provinces have adopted these policies over the past two decades.[3] Canada provides a useful point of comparison to the United States due to its geographic proximity and broadly similar policy landscape. Moreover, Canada's health surveys (the National Population Health Surveys, NPHS, and the Canadian Community Health Surveys, CCHS) contain far more detailed information on helmet use and bicycling than comparable US surveys. These factors allow us to fill important knowledge gaps in the previous literature and provide new evidence on the effects of all-age helmet laws on helmet use, bicycle riding, and related health behaviors and health outcomes. The very large samples of the Canadian survey data (we observe over 775,000 respondents) also allow us to meaningfully test for treatment effect heterogeneity. We use the staggered timing of adoption of the provincial helmet laws to estimate difference-in-differences models of the effects of laws on outcomes.

To preview, our two-way fixed effects models with controls for province and year fixed effects, individual characteristics, and other potentially relevant public policies confirm prior research from the United States that youth-targeted helmet laws in Canada were associated with at most modest estimated declines in youth cycling and extremely large increases in youth helmet use. When we examine the effects of all-age helmet laws, we find no relationship with youth cycling. All-age helmet laws did, however, significantly increase youth helmet use by around 30 percentage points or nearly 200 percent. We also find that all-age helmet laws were unrelated to adult cycling participation or intensity. We do find, however, that all-age helmet laws significantly increased the probability that adults report always wearing helmets while bicycling by around 19.7-24 percentage points, or about 50-65 percent relative to the average

[3] Newfoundland and Labrador adopted an all-age law after the CCHS redesign that changed the reference window of the exercise and helmet use variables. As well, some large towns in Newfoundland adopted all-age helmet laws during the period covered as well as a few small towns in other provinces and territories.

helmet use prior to adoption.[4] These effects of all-age helmet laws on adult helmet use are highly robust and are larger for younger adults (age 18-35), and less educated adults. We also examine helmet law effects on other exercise behaviors, and we uncover some evidence that during the winter months in Canada all-age helmet laws are associated with reductions in cycling and substitution toward in-home exercise.

Finally, we employ a variety of tests for role-modeling effects, asking whether adults with children in the household are particularly responsive to helmet laws because they want to set good examples for their children. We find some evidence in favor of role-modeling behaviors: the effect of all-age helmet laws on adult helmet use are larger in both absolute and proportional terms (relative to pre-reform levels) for individuals with children age 0-11 in the household compared to individuals without children age 0-11 in the household. Overall our findings suggest that all-age helmet laws can be effective at increasing population helmet use – even among adults – with little or no adverse effects on cycling and related health behaviors.

The paper proceeds as follows: Section 2 discusses the relevant literature and institutions on bicycle helmet laws, Section 3 describes the data and research design, Section 4 presents the results, and Section 5 offers a discussion and concludes.

2. Institutional Background and Relevant Literature

The types of laws we study here generally require individuals to wear a helmet when cycling on public roadways. Table 1 provides a list of the provinces and cities in Canada that adopted different types of helmet laws. Unlike the United States which has no statewide all-age helmet laws, most bicycle helmet laws in Canada apply to individuals regardless of age. Three

[4] If we do not restrict attention to cyclists, we still estimate that all-age helmet laws were associated with statistically significant increases in population helmet use rates on the order of 35 percent relative to pre-reform levels.

provinces – Ontario, Manitoba, and Alberta – adopted youth-only helmet laws over our sample period. Fines vary across provinces and range from $21 per offense in New Brunswick and $29 in British Columbia to $175 in Prince Edward Island. Enforcement varies across location, but there is evidence that police do write tickets for violations: for example, between 2006 and 2011 Vancouver police issued 7,871 tickets for violations of the province's all-age helmet law (Vancouver Sun 2012).[5]

We are not aware of any previous quasi-experimental economics research on the effects of all-age helmet laws. Even for youth helmet laws, however, we are aware of only three studies in economics that use explicitly quasi-experimental approaches to examine the effects of youth bicycle helmet laws on various cycling-related outcomes. Grant and Rutner (2004) use data on bicycle-related fatalities from the FARS and a two-way fixed effects empirical approach. Their models indicate that state helmet laws applying to youths in the United States significantly reduced youth bicycling fatalities by about 11 percent over the period 1990-2000. Carpenter and Stehr (2011) replicate and update Grant and Rutner's basic finding that youth bicycling fatalities fell by about 9 percent from 1991-2005. Carpenter and Stehr also use data on parental reports of child helmet use and cycling behaviors and high school youths' self-reports of helmet use and cycling behaviors in a triple differences framework (taking advantage of the fact that youths just above a state's helmet law age threshold are not subject to the law) to show that youth-targeted helmet laws in the United States increased helmet use by youths but also significantly reduced cycling participation by 3 to 4 percent. Finally, Chatterji and Markowitz (2015) use hospital-level panel data and estimate that helmet laws are associated with reductions in bicycle-related

[5] There are active enforcement and education campaigns in various locations (e.g., PEI issues hundreds of tickets in a month-long campaign called 'Operation Headway'), but we do not have comprehensive information on their timing or extent.

head injuries among children but increases in head injuries from other wheeled sports, also pointing to likely substitution toward other unregulated activities.

In contrast to the small number of studies in economics on the effects of bicycle helmet laws, there are large public health and medical literatures that have examined the effects of bicycle helmet laws – including several studies that have examined Canada. These studies are too numerous to review individually here (see, for example, Hagel et al. 2006, LeBlanc et al. 2002, Karkhaneh et al. 2011, and others), but a few merit further discussion. For example, two recent public health studies in Canada related provincial legislation to bicycle-related injury rates using data on inpatient hospital stays. Dennis et al. (2013) find no independent effect of helmet legislation on the rate of hospital admissions for cycling-related head injuries using data from 1994-2008. Teschke et al. (2015) similarly find that helmet legislation was not associated with hospitalization rates for brain, head, scalp, skull, face, or neck injuries using data from 2006-2011. Neither of these studies directly examines the underlying mechanisms (i.e., cycling and helmet use behaviors).

Foss and Bierness (2000) evaluated the effects of the British Columbia all-ages helmet law in September 1996. They studied 17 communities in the summer of 1995 and 12 of those 17 communities in 1999 (i.e., 3 years after law adoption) and, using the physical observation method, they found large increases in helmet use. Foss and Bierness also estimate that the increases in helmet use increased to a similar degree across the (visually inferred) age distribution, with possibly larger increases for adults estimated to be greater than 50 years of age. An obvious limitation of physical observation studies is that estimates of characteristics like age are likely to be imperfect, while other relevant characteristics such as education and the presence of children in the person's household are impossible to observe in this way. Our use of detailed survey data helps us address these key questions.

Finally, a recent study estimated the relationship between provincial helmet laws and both helmet use and cycling in Canada using some of the same CCHS data we use below (Dennis et al. 2010). They use one wave of CCHS helmet use data and find in that single cross-section that mandatory all-age helmet laws and mandatory youth-only helmet laws were both associated with increased helmet use among adults. They also use multiple waves of CCHS data and find no evidence of cycling reductions in either cross-province comparisons or when examining within-province policy changes.

Our work complements and extends the prior literature in several key ways. First, and most importantly, we provide the most comprehensive analysis of all-age and youth-targeted helmet laws by taking an explicitly quasi-experimental approach for all cycling and helmet use outcomes by relying on within-area adoptions of helmet laws to examine both helmet use and cycling throughout the entire population of Canada over a two decade period. Second, we incorporate earlier NPHS data that begins in 1994 in order to take advantage of a key provincial helmet law adoption applying to all ages in September 1996 in the highly populated province of British Columbia and another in Ontario in October 1995 that applied to youth only. Third, we use our large sample sizes to separately examine whether helmet laws have heterogeneous effects across demographic groups. Fourth, we examine more dimensions of cycling than in prior work (e.g., intensive margin of cycling, participation in other types of exercise, and body weight). Finally, we examine possible role-modeling effects by explicitly accounting for the role of children in the household.

3. Data Description and Research Design

We use two data sources to estimate the effects of mandatory helmet laws on helmet use and bicycle riding behaviors. Our first data are restricted use versions of the National Population Health Surveys (NPHS) from 1994 to 1999.[6] The NPHS data are akin to the National Health Interview Surveys in the United States and include information on demographic characteristics and questions about a variety of health behaviors, including bicycling. We complement the NPHS with data from the Canadian Community Health Surveys (CCHS) from 2000 to 2014.[7] The NPHS provided both longitudinal and cross-sectional information in its first 3 cycles, but the cross-sectional component of the NPHS was replaced by the CCHS. We use the NPHS in its repeated cross-section form to take advantage of the fact that there were large provincial 'buy-ins' in the 1996-97 NPHS that substantially increase sample size in key provinces such as Ontario. Previous work has used the NPHS in a similar fashion (see, for example, Stabile et al. 2006 and Carpenter and Eisenberg 2009).

The NPHS and CCHS contain several questions about helmet use, bicycle riding, and other types of exercise that we use to create key outcome variables. Specifically, the surveys include a section on Physical Activities in which respondents are asked: "Now I'd like to ask you about some of your physical activities. To begin with, I'll be dealing with physical activities not related to work, that is, leisure time activities. Have you done any of the following in the past 3 months?" The interviewer then reads a list that includes several activities such as "walking for exercise", "gardening, yard work", "swimming", "bicycling", "popular or social dance", "home

[6] This period reflects three waves of data: 1994-1995, 1996-1997, and 1998-1999.

[7] This period reflects multiple waves: Cycle 1.1 (fielded in 2000-2001), Cycle 1.2 (fielded in 2002), Cycle 2.1 (fielded in 2003), Cycle 3.1 (fielded in 2005), CCHS 2007-2008, CCHS 2009-2010, CCHS 2011-2012 and CCHS 2013-2014. Unfortunately, there was a major redesign of the CCHS in 2015 and the reference window for the exercise questions was change from "previous 3 months" to "previous year". Subsequently, the reference window for the helmet use question was also impacted. Therefore, we do not use the 2015-2016 CCHS for our analysis.

exercises", "jogging/running", and others; the interviewer is instructed to mark all that apply to the respondent. For each activity the respondent indicates "yes" to, the interviewer asks two follow up questions: "In the past 3 months, how many times did you participate in [the activity]?" and "About how much time did you usually spend on each occasion?" No response options are read aloud, but the interviewer is instructed to record responses in the following categories: "1 to 15 minutes", "16 to 30 minutes", "31 to 60 minutes", and "more than an hour". Importantly, respondents are asked only to list activities for this first set of outcomes that were explicitly for leisure-related purposes. Regarding helmet use, if the respondent indicated "bicycling" as a leisure time activity in the first set of physical activity questions, the individual was then asked: "When riding a bicycle how often did you wear a helmet?" The following response options are read aloud: "Always", "Most of the time", "Rarely", and "Never".[8]

We create several bicycling outcomes based on these questions. First, we create an indicator variable called *Any Past 3 Month Cycling* which equals one if the respondent reported any leisure cycling in the past 3 months (and zero otherwise). We then combine the information from the questions about the number of times of leisure cycling and the length of cycling on each occasion (using midpoints of ranges and assigning a value of 1.5 hours to respondents who say they cycle for more than an hour on each occasion) to create an outcome variable representing cycling intensity called *Total # Minutes Leisure Cycling Past 3 Months*. We also create two helmet use outcomes based on responses to the question about frequency of helmet use. The first is *Frequent Helmet Use* that equals one if the respondent reported wearing a helmet "always" or

[8] Individuals in some survey waves were also asked about non-leisure cycling such as cycling to school or work. Unfortunately, the wording of these questions changed over time in ways that prohibit us from analyzing them in a quasi-experimental framework. For the survey waves where the number of minutes of non-leisure cycling are calculated using the analogous questions used for the number of minutes of leisure cycling (CCHS 2007 to 2014), we estimate that approximately 89 and 96 percent of total minutes cycled for adults and youth respectively are leisure-related. Thus, leisure cycling represents the vast majority of total cycling.

"most of the time" when riding a bicycle (and zero otherwise). The second is *Always Helmet Use* that equals one if the respondent reported always wearing a helmet (and zero otherwise). Throughout, we restrict attention to individuals in the NPHS and CCHS with no missing data on the demographic characteristics or key helmet use and cycling questions.[9] We also drop a small number of individuals interviewed within the first three months of the law being in effect since the law would fall partway through the reference window for cycling and helmet use.

The CCHS and NPHS data also allow us direct measures of the possible unintended adverse consequences of mandatory helmet laws, as prior work has found that youth helmet laws reduced youth cycling in the US. In addition to the cycling outcomes, we also examine other exercise, weight, and obesity outcomes as further tests of these possible unintended consequences. We discuss the exercise outcomes below, but we construct them in an identical fashion to the extensive and intensive margins of cycling as described above. For body weight we use the standard body mass index variable (which equals weight in kilograms divided by height in meters, squared).[10]

Over the NPHS survey period (1994-1999) three Canadian provinces instituted all-age mandatory bicycle helmet laws (New Brunswick on December 15, 1995; British Columbia on September 3, 1996; and Nova Scotia on July 1, 1997). Over the CCHS survey period (2000 to 2014) one Canadian province adopted a mandatory bicycle helmet law for all ages (Prince Edward Island on July 5, 2003). A few towns in Newfoundland and Labrador adopted all-age

[9] In the NPHS, individuals age 0 to 11 are sampled but are dropped from our analysis since they are not asked several key questions. Individuals age 0 to 11 are not sampled in the CCHS. In the CCHS 1.2, individuals 12 to 14 are also not sampled.

[10] If the helmet law did discourage someone from cycling completely (and assuming no equivalent substitution to another exercise), there could be a substantial decrease in calories expended over the year. For example, calculating a few hypothetical figures for calories burned (https://www.bicycling.com/health-nutrition/a20046377/cycling-calories-burned-calculator/) using the mean number of minutes cycled for an adult cyclist from Table 2, for a 160 pound individual, this would suggest that depending on the pace, they could see a decline in annual calories expended by 17,013 (slow pace/<10 MPH), 25,520 (medium pace/10-12 MPH), 42,592 (fast pace/14-16 MPH) or 68,112 (very fast pace/>20 MPH).

helmet laws, with the provincial capital city St John's in June 1994, Corner Brook in May 2008 and Conception Bay South in June 2010.[11] We account for these local laws in the policy coding. As well, while the Yukon does not have a law, the capital city, Whitehorse adopted an all-age law in July 2003.[12]

Three provinces over our sample period also adopted youth-only helmet laws similar to those adopted more commonly in the United States: Ontario did so in 1995, Alberta adopted a youth-only helmet law in 2002, and Manitoba's youth-only helmet law came into effect in 2013 (see Table 1).[13] Our confidential NPHS and CCHS data provide us information on exact interview date (which we need to precisely match the timing of provincial helmet legislation) and respondent age in years. This within-province variation allows us to evaluate the effects of all-age bicycle helmet laws in Canada in the same basic framework as for previous US analyses.

We begin by estimating two-way fixed effects models separately for youths age 12-17 and for adults ages 18-64. This amounts to the following linear probability model for binary outcomes and OLS for continuous outcomes:

(1) $Y_{ipt} = \beta_0 + \beta_1 X_{ipt} + \beta_2(\text{All-Age Bicycle Helmet Law})_{pt} + \beta_3(\text{Youth-Only Bicycle Helmet Law})_{pt} + \beta_4 Z_{pt} + \beta_5 P_p + \beta_6 T_t + \varepsilon_{ipt}$

where Y_{ipt} are the outcomes of interest for individual *i* in province *p* in year *t*. X_{ipt} is a vector of individual characteristics that includes: age, sex, race, education, and marital status. Z_{pt} is a vector of province/time varying covariates including the provincial unemployment rate and an

[11] In April 2015, just after the period covered by our analysis, Newfoundland and Labrador adopted a provincial wide all-age helmet law.
[12] Yorkton, Saskatchewan also has had an all-age helmet law since 1995, and North Battleford, Saskatchewan also has had an all-age helmet law since October 14, 2003.
[13] Yellowknife (the capital city of the Northwest Territories) introduced a youth helmet law at the end of the period covered by our data (July 2014) but provided a 6-month grace period, so we do not include this law. St. Albert, Alberta and Côte Saint-Luc, Quebec are the only locations that went from a youth law to an all-age law. We do not include Westmount or Côte Saint-Luc as having helmet laws in the estimates presented since they are subdivisions in the core of Montreal. The overall estimates are not impacted by this restriction.

indicator for whether the individual lives in a place that adopted a public bike-share program such as Bixi[14] and when a provincial graduated license policy came into effect. P_p and T_t are a full set of province and year dummies, respectively. Though not reported in equation (1), we also include month of interview dummies in all models to account for seasonality in bicycling and other physical activities. In some models we also allow for province-specific linear time trends. All-Age Bicycle Helmet Law is an indicator variable equal to one if the respondent lives in a province that had a mandatory helmet law covering individuals of all ages over the previous 3 months, and Youth-Only Bicycle Helmet Law is defined analogously.[15] The coefficient of interest, β_2, captures the relative effect of the mandatory all-age helmet law on outcomes use by comparing within-province changes in outcomes for individuals in helmet adopting provinces coinciding with the law taking effect to the associated changes in outcomes for individuals in provinces that did not experience a policy change in that year. β_3 shows the corresponding effect of the Youth-Only Bicycle Helmet Law.[16] Note that the All-Age and Youth-Only law indicators are mutually exclusive. We report two p-values for each core estimate: one reflecting provincial level clustering and one using the Wild bootstrap procedure with Rademacher weights with 1499 bootstraps to account for the small number of clusters (Cameron et al. 2008; MacKinnon and Webb 2017).

[14] These include: Montreal (Bixi in operation since May 12, 2009), Toronto (BikeShare in operation from 2001 to 2006; Bixi in operation since May 3, 2011), Edmonton (Peoples' Pedal in operation from 2005 to 2008), and Ottawa-Gatineau (Bixi in operation since June 2009 with a temporary stoppage in service). Hamilton began a bike-share program in 2015, and Vancouver began one in 2016.

[15] This time window is chosen to account for the wording of the question.

[16] Unfortunately given the timing of the policy variation relative to the timing of our data and the small number of provinces adopting helmet laws, a more flexible event study specification is not informative in this context. We do explore robustness to controlling for leads of the helmet law policy variable, however, and we describe those analyses below.

4. Results

a. Descriptive Patterns

Figure 1 presents the age profile of cycling and helmet use in Canada from our NPHS and CCHS data. It shows that cycling declines with age, while the likelihood adults report always wearing a helmet while cycling is low (around or below ten percent) and relatively stable across the adult population. Figure 2 shows trends in these same key outcomes over time from 1994 to 2014 for 12-17 and 18-64 year olds. It also indicates that population rates of leisure cycling have remained relatively flat over the sample period while the proportion of children and adults who report always wearing helmet while cycling has increased.

Table 2 presents means of key variables for the NPHS and CCHS, respectively. About 23 percent of adults and 49 percent of children age 12-17 report leisure cycling. On average, adults report about 203 minutes of cycling (i.e., about 3.5 hours) in the past three months, while children report 625 minutes; among cyclists, the average number of minutes cycled is 880 minutes for adults and 1268 minutes for children. Among cyclists, 49 percent of adults and 35 percent of children report never wearing a helmet when they rode a bike, while only around 35 percent of adult and child cyclists report that they always wore a helmet. About 18 percent of individuals live in a province that had an all-age helmet law, while about 47 percent live in a province that had a youth-only helmet law.

Figures 3a and 3b show the provincial specific trends for bicycling participation and helmet use among cyclists for the four most populous provinces that adopted laws. Three of the provinces adopted the youth-only bicycle helmet law (Alberta, Manitoba and Ontario), while British Columbia adopted an all-age law. The dashed line presents the results for the 12 to 17 year olds while the solid lines present the results for 18 to 64 year olds. We include a vertical line to indicate when the given provincial specific helmet law was put in place.

From Figure 3a, there does not appear to be any evidence that either the youth-only or all-age helmet laws reduced cycling participation.[17] Conversely, Figure 3b shows a large change in helmet use among cyclists when a law comes into effect that impacts cyclists for the targeted age group. While there is a general upward trend in helmet use among adults in places where no all-age helmet laws are implemented, there is a large discrete increase in British Columbia when the all-age law comes into effect and not much subsequent increase in helmet use after the law comes into effect. The increase in helmet in the few months just prior to the helmet law for adults in British Columbia may be due to people purchasing (and using) helmets in response to the law coming into effect.[18]

b. Main Effects on Cycling and Helmet Use, Robustness, and Heterogeneity

In Table 3 we present the basic difference-in-differences results regarding the effects of all-age and youth-only bicycle helmet laws on cycling and helmet use of 12-17 year olds in Canada using the NPHS and CCHS data. In the presence of year and province dummies (and linear province trends in some models), we are effectively identifying the effects of helmet laws from the various provinces that adopted helmet laws over our sample period: Alberta, British Columbia, Manitoba, New Brunswick, Nova Scotia, Ontario, and Prince Edward Island. The format of Table 3 is as follows. Each column is a separate regression and shows the coefficient estimates on the All-Age Bicycle Helmet Law and Youth-Only Bicycle Helmet Law indicators

[17] For Manitoba, given the timing of the youth-only law, we split the 2013 CCHS and code the first four months with 2012 and the remaining relevant months as 2013.

[18] Note that the all-age law in British Columbia came into effect during the second cycle of the NPHS. For adults, the sample size was large enough to code a separate mean in the months just prior to the law coming into place. Conversely, for youth, the sample size was too small so we include these observations with the first cycle NPHS mean.

in a difference-in-differences model. In the odd numbered columns we show estimates from models that include all the demographic characteristics (i.e., the X vector), the province-time varying controls (e.g., Bixi, provincial unemployment rates), and the province and year dummies, and in the even numbered columns we add linear province-specific time trends. We also report above the relevant coefficient estimate the mean of the outcome in the three years prior to helmet law adoption, and below the coefficient estimate we report the implied percentage change as a proportion of the pre-reform mean. As noted above, we report p-values using province-level clustering of the standard errors in parentheses and p-values using the wild bootstrap with 2-point Rademacher weights and 1,499 replications in brackets.[19] For the first two tables with regressions estimates (Tables 3 and 4) we also show the p-values using the wild bootstrap with 6-point weights in curly braces to demonstrate how similar they are to the p-values from the wild bootstrap with 2-point Rademacher weights (see Webb 2014). However, to conserve space, we do not present them in subsequent tables. We examine cycling outcomes in columns 1-4 and helmet use outcomes in columns 5-8.

The results in columns 1-4 of Table 3 for youths indicate that helmet laws in Canada had at most modest effects on cycling behaviors of youths. Specifically, we estimate in columns 1 and 2 that all-age helmet laws are not significantly related to leisure cycling participation of 12-17 year olds, and in fact the point estimate is positive in sign, suggesting the all-age helmet laws are associated with more youth cycling, though neither estimate is statistically significant. In contrast, there is some evidence that the youth-targeted helmet laws reduced youth cycling by about 2.4 percentage points – consistent with prior work on similarly policies in the United States (Carpenter and Stehr 2011) – but the statistical significance of the estimate is sensitive to

[19] We also present p-values from F-tests for the main youth estimates to test if the All-Age Bicycle Helmet Laws and Youth-Only Bicycle Helmet Laws have similar impacts on youth cycling and helmet use.

clustering on province versus implementing the wild bootstrap procedure and to the inclusion of linear province trends. The point estimate suggests a five percent reduction in cycling participation for youths relative to the pre-reform mean, which is nearly identical to prior estimates for the United States (Carpenter and Stehr 2011). Turning to cycling intensity for 12-17 year olds in columns 3 and 4 we find no evidence that all-age helmet laws were associated with statistically or economically significant reductions in youth cycling. As with cycling participation, we do find some evidence that youth-targeted helmet laws were associated with modest reductions in cycling (a 14 percent effect relative to the pre-reform mean for the youth-only helmet law in column 4 with linear provincial trends), though none of the estimates are statistically significant. Overall, we find in columns 1-4 of Table 3 that all-age helmet laws did not adversely affect youth cycling and that youth-only helmet laws may have been associated with modest declines in youth cycling, though those estimates are not precise.

Turning to youth helmet use in columns 5-8 of Table 3 we find a more consistent story. Given the lack of systematic reductions in cycling in columns 1-4, the models in columns 5-8 restrict attention to youths who report any past three month leisure cycling, though results are qualitatively similar if we include non-cyclists and examine effects on population helmet use behaviors (see Appendix Table 1). Specifically, we estimate that both types of helmet laws were associated with statistically significant increases in the likelihood that youths in Canada age 12-17 reported wearing helmets when cycling. These effects obtained for both types of helmet laws, are not sensitive to using the wild bootstrap, and are not sensitive to inclusion of linear provincial trends. Moreover, the effects are large: all-age helmet laws in column 6 with provincial linear trends are associated with a 31.6 percentage point increase in the likelihood a youth age 12-17 reports always wearing a helmet when cycling. Relative to the pre-reform mean of 17.6 percent, this is a 180 percent effect. For youth-only laws in the same specification we estimate that the helmet requirements are associated with a statistically significant 24.3 percentage point increase. Relative to a pre-reform mean for this policy of 23.9 percent, this is a 100 percent effect. Overall, the patterns in Table 3 confirm prior work using data from the US: youth-targeted helmet laws might modestly reduce youth cycling, but they also induce very large increases in youth helmet use.[20] Moreover, the patterns in Table 3 uncover new evidence about how all-age helmet laws affect youths: those policies have no effects on youth cycling and also induce very large increases in youth helmet use.

We turn to the main results for adult cycling and helmet use behaviors in Table 4, the format of which follows Table 3 exactly. The results in columns 1-4 for cycling behavior of adults return no systematic evidence that all-age or youth-targeted helmet laws reduced adult cycling participation or intensity.[21] While one of the estimates is statistically significant using province-level clustered standard errors (also suggesting a modest five percent reduction in cycling relative to the pre-reform mean), it is not robust to the treatment of linear provincial trends or to the wild bootstrap. We similarly find no evidence of decreases in cycling intensity – defined as the total number of minutes the person reported cycling for leisure in the past 3 months – in either column 3 or column 4. Thus, we conclude that helmet laws in Canada did not greatly affect population cycling behaviors.

In columns 5-8 of Table 4 we present results for adult helmet use. We find that all-age helmet laws significantly increased the likelihood an adult age 18-64 reports always wearing a

[20] The p-values in Table 3 from the F-test for the All-Age and Youth-only laws coefficients being equal indicate that we cannot reject the null hypothesis.

[21] Although our primarily focus in the models predicting adult behaviors is on the all-age helmet laws, it is not implausible that a youth-targeted helmet law could also meaningfully affect adult cycling if parents and children enjoy bicycle riding together and youth-targeted helmet laws reduce youth cycling (i.e., if the cycling effects observed in Table 3 are real). Again, however, we primarily expect that adult cycling and helmet use behaviors will primarily respond to all-age helmet laws as opposed to youth-targeted helmet laws.

helmet while cycling by about 19.7 percentage points, or about 52 percent relative to pre-reform levels. Appendix Table 2 shows that including non-cyclists to examine effects on population helmet use returns qualitatively similar patterns. For youth-only helmet laws, we find smaller effects at increasing adult helmet use (possibly consistent with role modeling behavior, which we return to below), though these results are generally not robust to inclusion of linear provincial trends. In columns 7-8 for Frequent Helmet Use we find very similar patterns. Taken together, the results in Table 4 indicate that Canada's 'all-age' helmet laws significantly increased adult helmet use without causing major reductions in cycling.

In Tables 5 and 6 (for youths and adults, respectively) we investigate the robustness of the main findings from Tables 3 and 4 for the primary outcome Always Wears Helmet. We reprint the baseline estimate from the model without provincial linear trends in column 1 of Tables 5 and 6; we choose the model without trends as our preferred baseline specification because those estimates on helmet use were smaller in magnitude (i.e., more conservative). In column 2 of Tables 5 and 6 we report estimates from an augmented variant of equation (1) in which we add a control for an indicator variable for one year prior to the all-age helmet law that is intended to test for policy endogeneity and the validity of the parallel trends assumption. Column 3 of Tables 5 and 6 add linear province trends to the model with the one-year policy lead. Columns 4 to 6 of Tables 5 and 6 report results from models where we drop each of the three highly populated provinces that adopted helmet laws over our sample period: Alberta, British Columbia, and Ontario.[22]

[22] Results where we drop the less populated provinces were also very similar and are available upon request. Similar robustness analyses for the findings on youth and adult cycling behaviors are provided in Appendix Tables 3 and 4, respectively. Those analyses show some evidence that the modest reduction in youth cycling associated with youth helmet laws do not survive the exclusion of some of the highly populated provinces. Moreover, we estimate statistical significance on some of the policy lead indicators, suggesting potential violation of the parallel trends assumption required for identification in these models.

The results in Table 5 for youth helmet use confirm that the effects of both types of helmet laws at increasing youth helmet use are highly robust. In column 2 of Table 5 we find that the one-year lead coefficients are both very small in magnitude relative to the main policy effects of all-age and youth-only helmet laws, which remain large and statistically significant. Column 3 of Table 5 shows that this same pattern is unaffected by the inclusion of linear province time trends. Columns 4 to 6 of Table 5 show that the baseline estimates are not appreciably changed when we drop Alberta, British Columbia, or Ontario from the models. Turning to the robustness of the helmet use effects for adults in Table 6 we find qualitatively identical patterns to those in Table 5 for youths, further demonstrating that the effects of all-age helmet laws at increasing adult helmet use in Canada are robust.

In Tables 7 and 8 for youths and adults, respectively, we explore treatment effect heterogeneity. We again present results from the two-way fixed effects specification without provincial trends, as these estimates for helmet use increases were smaller (i.e., more conservative) in Tables 3 and 4.[23] Each column is from a separate regression where the outcome is Always Helmet Use. For youths we examine males vs. females in columns 1 and 2, urban vs. rural residents in columns 3-4, and winter versus summer months in columns 5-6. The results indicate that helmet laws had broad-based effects at increasing helmet use among youths, with somewhat larger effects during the winter months.

For adults in Table 8 we examine more sources of heterogeneity. Specifically, we examine 18-35 vs. 36-64 year olds in columns 1 and 2; males vs. females in columns 3 and 4; adults with at least a university (bachelor's) degree vs. some postsecondary education but less than a university (bachelor's) degree vs. high school degree or less in columns 5 to 7; urban vs.

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[23] Appendix Tables 5 and 6 for youths and adults, respectively, present heterogeneity analyses for the cycling outcomes which are generally null, with one notable exception we discuss below.

rural residents in columns 8 and 9, and winter vs. summer months in columns 10 and 11. We find that helmet use increases induced by all-age helmet laws were much larger for 18-35 year olds than for 36-64 year olds in columns 1 and 2. This could partly reflect an effect of cohort (as opposed to age) since the older people faced fewer public health and safety regulations when they were younger, and thus it may be more difficult to get them to comply with policies such as mandatory all-age helmet laws. We find very similar estimated effect sizes by gender in columns 3 and 4. Results by education in columns 5 to 7 reveal clear evidence of a gradient in the effects of helmet laws: all-age helmet laws had effects that are larger for less-educated adults. Columns 8 and 9 reveal similar estimated effects by urban vs. rural status, though in proportional terms the helmet law effects are larger for rural residents where helmet use rates were lower in the pre-reform period. Finally, columns 10 and 11 reveal noticeably larger increases in helmet use in the winter months compared to the summer months in response to helmet laws. Appendix Table 6, however, also reveals that the one source of treatment effect heterogeneity that returns economically and statistically meaningful evidence of cycling reductions in response to all-age helmet laws is the winter vs. summer distinction: all-age helmet laws are estimated to reduce the probability adults report leisure cycling in the winter months by nearly two percentage points off a base of 17.8 percent, or an 11 percent effect. In results not reported we continued to find helmet use increases were larger in the winter months even when we examined effects on population-wide helmet use (i.e., when we coded non-cyclists as zero for Always Helmet Use and added them back into the regression model in column 10 of Table 8).

c. Effects on other activities and weight

In Tables 9 and 10 for youths and adults, respectively, we investigate possible substitution effects to other types of leisure-related activities such as walking, jogging/running, and/or home exercise, as well as population weight. For youths in Table 9 we find relatively consistent evidence that youth helmet laws were associated with significant reductions in recent participation in both walking and jogging. These patterns are somewhat surprising since they suggest that youths did not substitute toward walking or jogging in response to the reduced cycling induced by helmet laws. Instead, the patterns are more consistent with overall reductions in these types of physical activities and/or that youth cycling and other types of youth exercise are complements. Despite this, we do not estimate meaningful changes in youth weight associated with youth helmet laws.

For adults in Table 10 we present a slightly different set of results. Specifically, we show the intensive margin (i.e., # minutes) of various exercise activities separately for the winter months (October to March) and for the summer months (April to September). The motivation for doing so is that the cycling heterogeneity effects in Appendix Table 6 revealed fairly strong evidence that adult cycling participation fell in the winter months in response to all-age helmet laws. Columns 1-2 of Table 10 show that this same pattern observed for cycling participation also obtains for cycling intensity for adults: all-age helmet laws are associated with significant reductions in the number of minutes adults report leisure cycling during the winter months by about fifteen minutes in the past three months, or about 11 percent relative to the pre-reform mean. In contrast, the estimated coefficient for the summer months is positive and sizable (which might indicate cross-year substitution in activity type), but it is not statistically significant. In the later columns of Table 10 we present the associated intensive margin effects by winter/summer months for walking (columns 3 and 4), jogging (columns 5 and 6), and home exercise (columns 7 and 8). Notably, there is some evidence that all-age helmet laws are associated with significantly more jogging minutes during the summer months but not during the winter months. There is also evidence that all-age helmet laws are associated with significantly more home exercise minutes during the winter months but not the summer months. This pattern is consistent with cycling and home exercise being substitutes. Finally, when we examine population weight in columns 9 and 10 we estimate that all-age helmet laws were not associated with meaningful changes in weight during the winter months but were associated with significant *reductions* in weight during the summer months. Again, this could reflect cross-year substitution of types of physical activity in response to helmet laws.

Overall, the patterns in Tables 9 and 10 do not suggest there were major unintended adverse consequences of helmet laws with respect to objective measures of health, though there is modest evidence of changes in related activities: youths seem to do less of many types of exercise activities in response to youth helmet laws, while adults engage in some cross-activity (and possibly cross-year) substitution in response to all-age helmet laws.

d. Role-modeling effects

Finally, in Table 11 we investigate whether there is evidence for role-modeling effects by examining whether the effects of helmet laws vary by the presence of children in the household. One reason for investigating the role of children is the well-documented correlation between adult and child helmet use. If these correlations reflect role model effects, then it would be interesting to know whether all-age or youth-targeted helmet laws induce larger effects for adults with kids in the household relative to adults without kids in the household. Of particular interest to us is the fact that three provinces – Alberta, Manitoba and Ontario – adopted youth-only helmet laws over our sample period (Alberta in May 2002, Manitoba in May 2013 and Ontario in October 1995). In the presence of strong role model effects we might expect that parents' helmet use behaviors improve even when they are not directly targeted by the helmet law policy in question in order to set positive examples for children about the importance of helmet use, compliance with the law, or both.

The format of Table 11 is as follows: each column is from a separate regression, and we focus on the Always Helmet Use outcome in all models. Because of our focus on adults with children in Table 11, we restrict attention to 25-50 year olds (reasoning that few 50-64 year olds will have children in the targeted age group). Column 1 reports results for this restricted sample (25-50 year olds) and confirms that this sample restriction has no meaningful effect on the bottom line conclusion from Table 4 that all-age helmet laws significantly increased helmet use. Columns 2 and 3 of Table 11 examine the role of children directly by presenting estimates for 25-50 year olds separately by whether the respondent has no children age 0-11 in the household (column 2) or has any children age 0-11 in the household (column 3).[24] Columns 4 and 5 take the sample from column 3 and separate it into adult respondents with only younger children in the household (any children age 0-5) versus adult respondents with only older children in the household (any children age 6-11). Finally, columns 6 and 7 report results for adults with any children age 0-11 in the household separately for male respondents who are likely to be fathers (column 6) and female respondents who are likely to be mothers (column 7).[25]

The results in Table 11 offer mixed evidence on the possibility of role model effects in the effects of helmet laws. Perhaps the strongest evidence in favor of role model effects would be that adults with children in the household wear helmets more frequently when their children are required to do so but they are not (i.e., youth-only helmet laws would significantly increase

[24] Due to data limitations, we cannot separately identify people with children age 12-17 in the household. However, the 'no children age 0-11 in the household' results are similar to estimates if we drop households with anyone younger than 25 in the household.

[25] A limitation of this analysis is that although we observe the age-profile of cycling starting at age 12 (see Figure 1), we do not observe the age-profile of cycling for 0-11 year olds. Thus, the 0-5 versus 6-11 year old heterogeneity should primarily be thought of as descriptive. We also do not observe the gender of the children in the household, which precludes us from analyzing interesting parent gender-by-child gender interactions.

helmet use for parents but not childless adults). We do not see strong evidence for this pattern in Table 11: while there is some evidence that 25-50 year olds are more likely to report always wearing a helmet while cycling after youth-only laws are adopted, the effect sizes do not differ meaningfully by presence of children age 0-11 in the household. We do, however, observe in columns 2 and 3 of Table 11 that all-age helmet laws are associated with larger estimated increases in helmet use for adults with children in the household than for adults without children in the household: a 42 percent effect for the former group versus a 32 percent effect for the latter group. That is, the effects of all-age laws are a third larger for adults with children age 0-11 in the household than for adults without children age 0-11 in the household.[26] Finally, the remaining columns of Table 11 show that there is not meaningful heterogeneity by the age of the child in the household (since helmet use estimates for adults with children age 0-5 in the household versus age 6-11 in the household are similar in size), nor is there a consistent story for differences between male and female adult respondents (i.e., likely fathers versus likely mothers).

5. Discussion and Conclusion

The results above show that laws requiring mandatory helmet use for individuals of all ages in Canadian provinces significantly increased helmet use among adults. To our knowledge, these are the first quasi-experimental results showing that all-age helmet laws can be effective at increasing helmet use. We estimate that all-age helmet laws significantly increased the probability that adults report always wearing helmets while bicycling by about 20 percentage

[26] Note that due to data limitations we cannot directly observe whether there are children age 12-17 in the household, so the 'no children age 0-11 in the household' sample could include adults with children age 12-17 but not 0-11 in the household, which would bias us against finding role model effects if they also existed for slightly older children age 12-17.

points, or by about 50 to 65 percent relative to pre-reform means. These effects on helmet use are larger for 18-35 year olds, less educated adults, and adults with children in the household. We find little systematic evidence that all-age helmet laws in Canada induced population-wide reductions in cycling. We find no effects on other potentially related leisure-related physical activities, nor do we find adverse effects on population weight. Overall our findings suggest that all-age helmet laws can be effective at increasing population helmet use with relatively little adverse effects on cycling.

There are some important limitations to the current study that should be noted. First, we did not control for the arguably important effects of enforcement, outreach, or media campaigns because we could not find objective measures of such efforts by province and year. The concern with, say, outreach is that adoption of a mandatory helmet law could be correlated with other state efforts to increase helmet use such as "helmet giveaways". Although this is a limitation shared by nearly all the other papers in this literature as well, we cannot rule out that the effects of helmet laws on use are upward biased by failing to control for outreach efforts by provinces with helmet laws, or downward bias if provinces that do not have helmet laws carry out other efforts to increase helmet use. Second, our outcomes are based on self-reports, and it is plausible that the true behavioral responses are smaller than the estimated effect we estimate here due to desirability bias. We do find some differences in the effects of helmet use across demographic groups, however, and we do not have strong reason to believe that the misreporting should vary by, say, season (where we find quite large differences in helmet use effects). Third, there may be slippage between the respondent's province of residence and the province where her cycling takes place. All of the maritime provinces (New Brunswick, Nova Scotia, and Prince Edward Island) have all-age helmet laws, and these are popular summer vacation destinations for residents of other provinces. This may lead to measurement error, particularly during the summer months.

Despite these limitations, our results provide the literature's first evidence that all-age helmet laws can significantly increase helmet use among adults. As more places actively consider adopting all-age bicycle helmet laws, our findings provide important new evidence that these public health improvements can be obtained with little adverse health effects.

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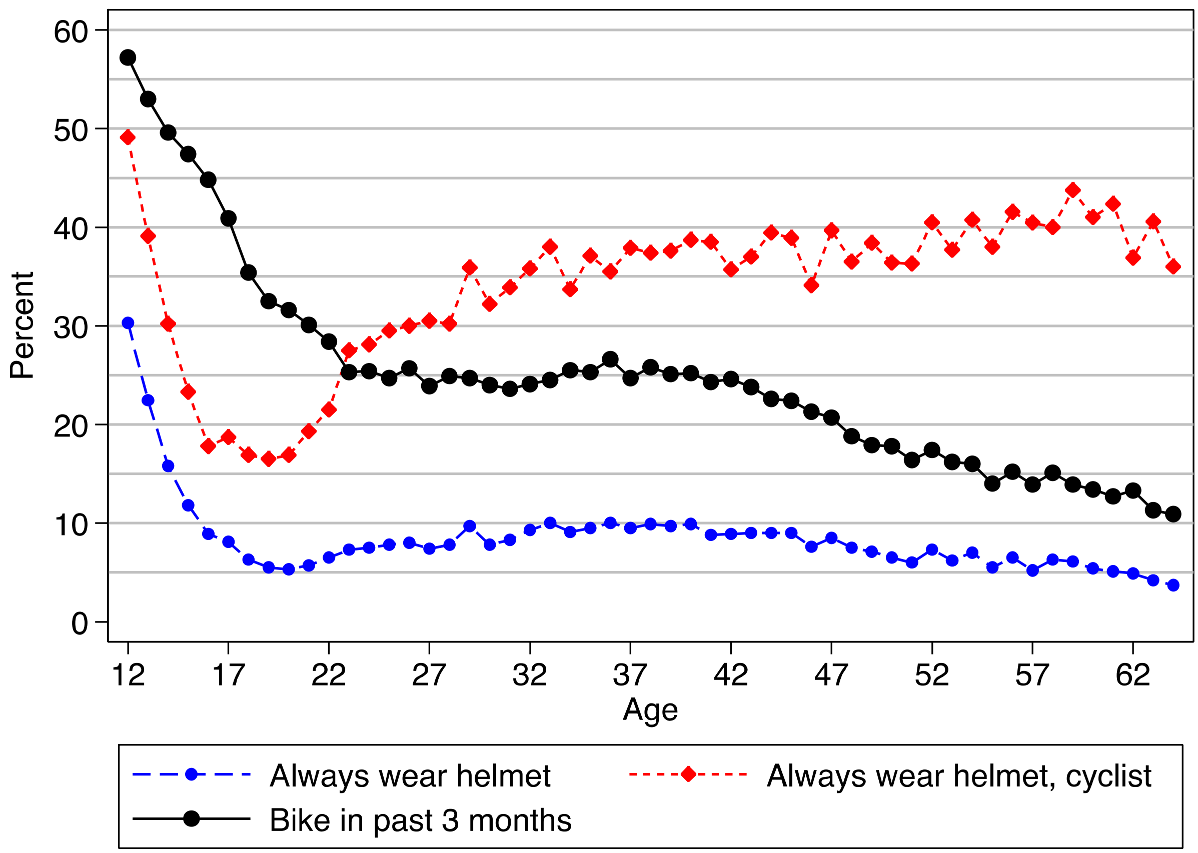
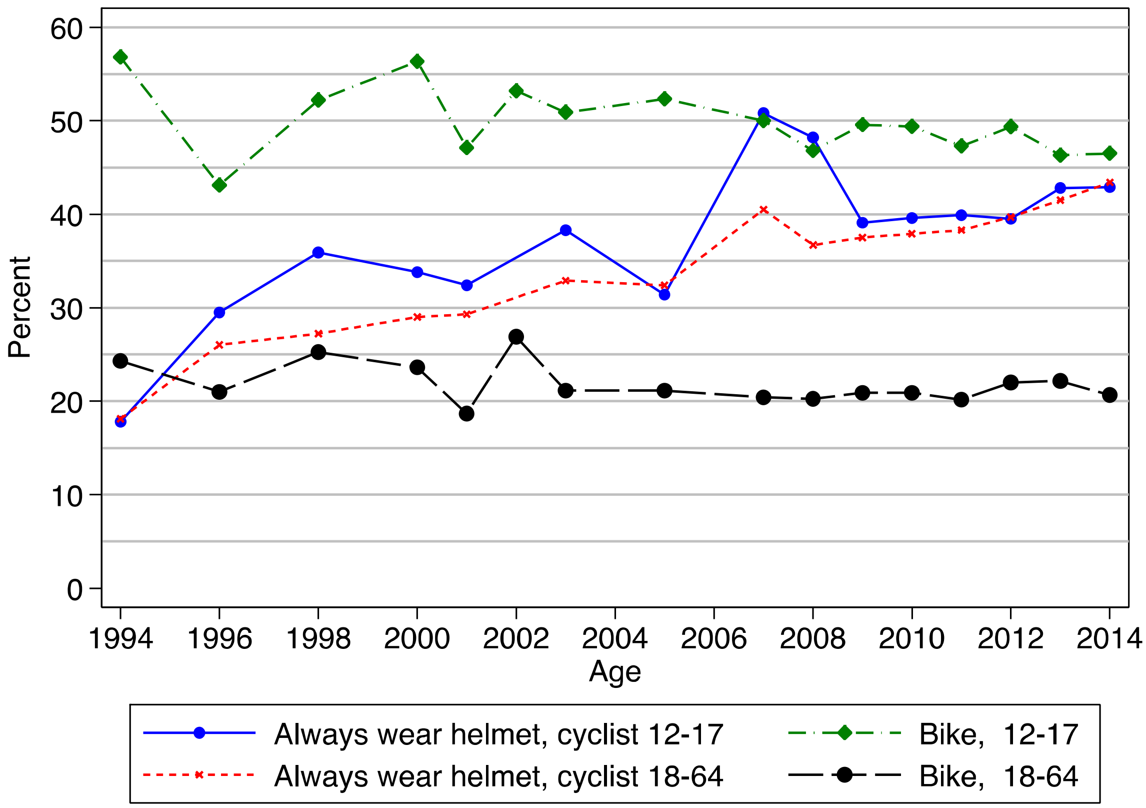
Figure 1: Age profile of bicycling participation for leisure and helmet use, 12 to 64 year olds NPHS and CCHS 1994 to 2014



Notes: Conditions on province of residence, with Ontario as the default category.

Figure 2: Trends in bicycling participation and helmet use, 12 to 17 and 18 to 64 year olds NPHS and CCHS, 1994 to 2014



Note: With controls for province of residence. Default category Ontario.

Figure 3a: Provincial trends in bicycling participation, 12 to 17 and 18 to 64 year olds NPHS and CCHS, 1994 to 2014

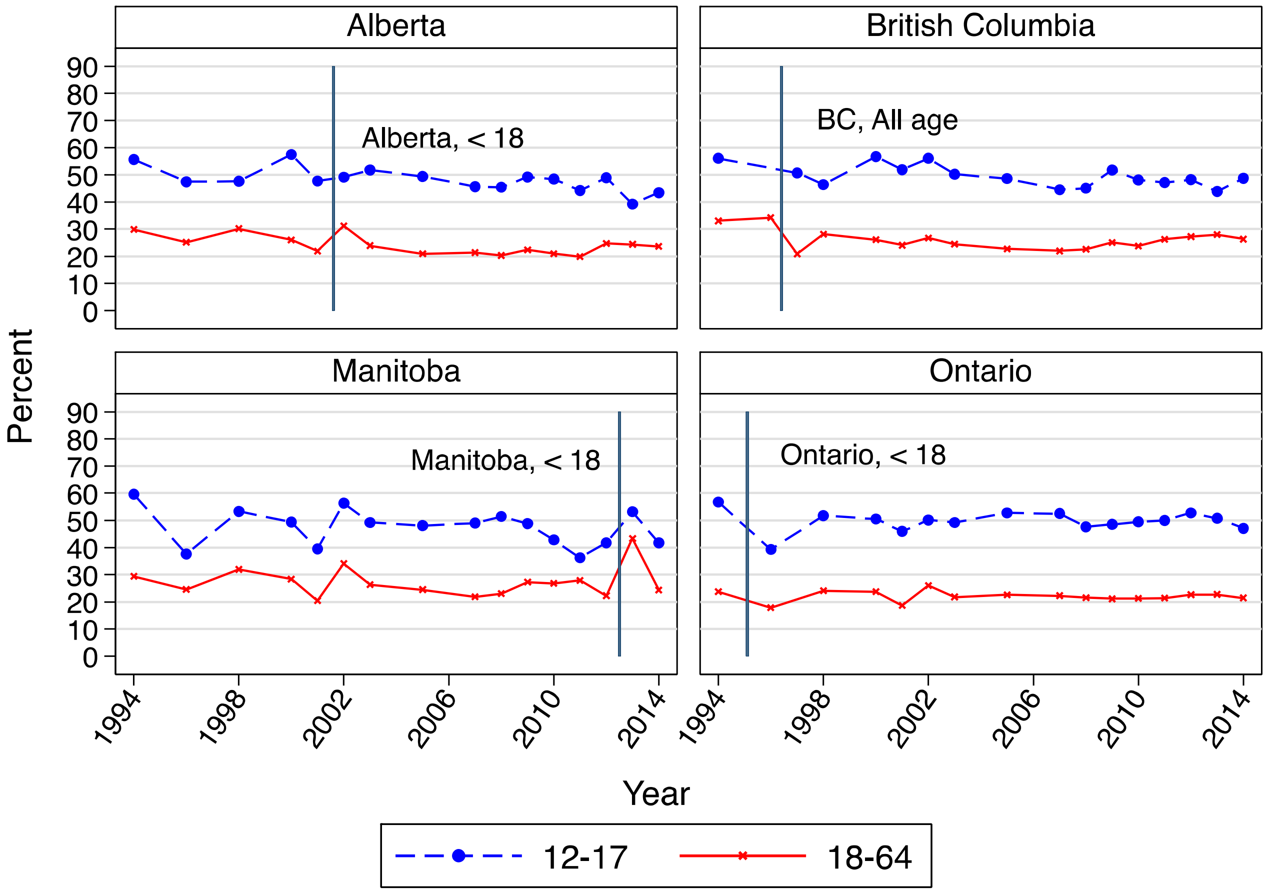


Figure 3b: Provincial trends in helmet use, 12 to 17 and 18 to 64 year olds NPHS and CCHS, 1994 to 2014

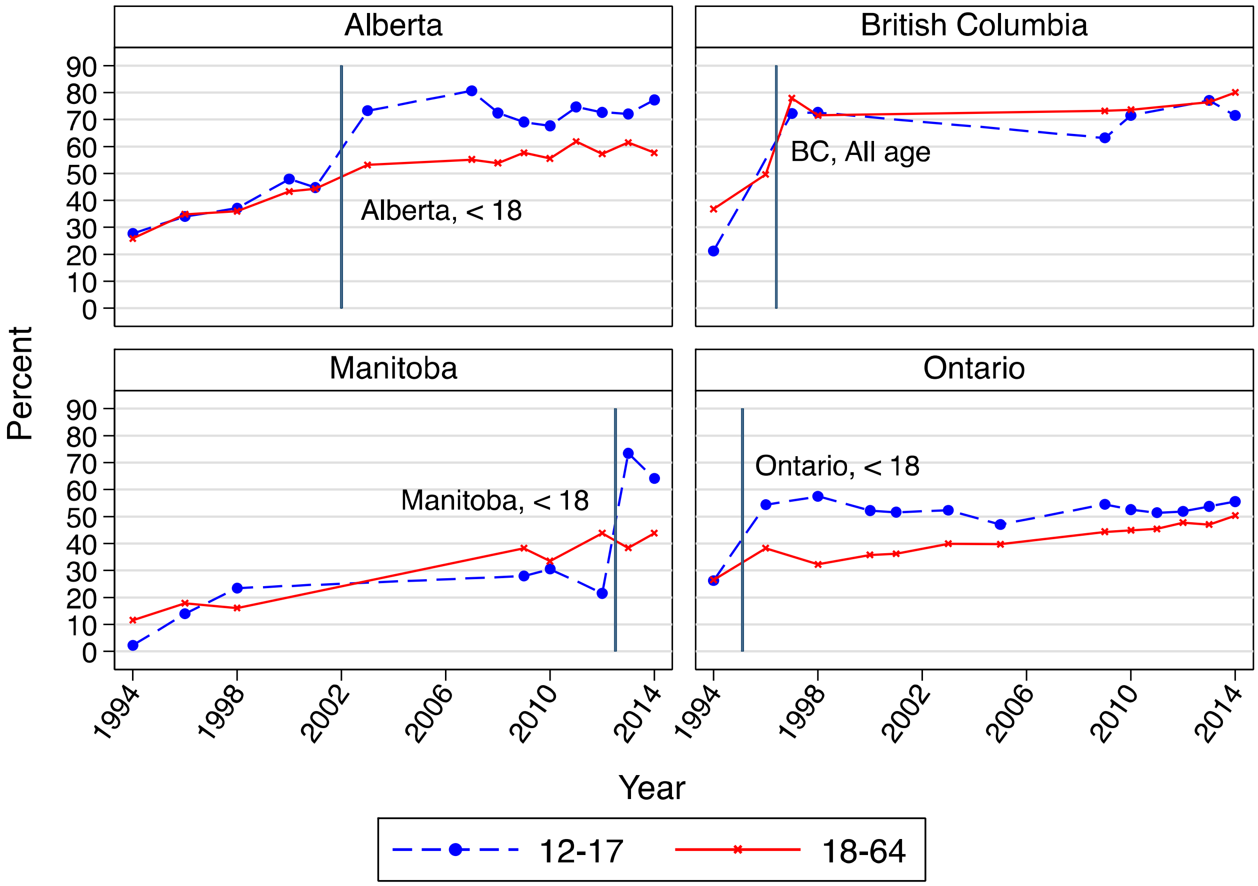


Table 1:
Bicycle Helmet Laws in Canada

Province or City	Ages Covered	Effective Date
Newfoundland[a]	All	April 1, 2015
Channel-Port aux Basques[b,f]	<=12	October 1, 1996
Conception Bay South[c]	All	June 16, 2010
City of Corner Brook[e]	All	May 5, 2008
Grand Falls-Windsor[d,g]	All	June 15, 2002
Holyrood[d,g]	All	December 1, 1994
Mount Pearl[d,g]	<=12	1994
Paradise[d]	All	1992
St. John's[d,h]	All	April 25, 1994
Prince Edward Island[i]	All	July 5, 2003
Nova Scotia[j]	All	July 1, 1997
New Brunswick[j]	All	December 15, 1995
Quebec	No	
Westmount[k]*	Not Enforced	1994
Côte Saint-Luc[l]*	<=16	June 14, 1993
Côte Saint-Luc[m]*	All	October, 1997
Ontario[n]	<18	October 1, 1995
Manitoba[o]	<18	May 1, 2013
Saskatchewan	No	
Yorkton[p,q,r]	All	1995
North Battleford[s]	All	October 14, 2003
Alberta[t]	<18	May 1, 2002
St. Albert[u]	All	July 1, 2006
British Columbia[v]	All	September 3, 1996
Yukon	No	
Whitehorse[w]	All	July 2003
Northwest Territories	No	
Fort Smith[x]	All	June 23, 2011
Inuvik[y]	All	Nov 9, 2011
Yellowknife[z]**	<18	July 1, 2014 (with 6 months grace period before tickets handed out)
Nunavut	No	

Source:

a. Highway Traffic Act, Chapter H-3, last accessed 2018-03-17

b. PortauxBasques (1996) Section 246, Municipalities Act 1990, last accessed 2018-03-04

c. Conception Bay South Bicycle Helmet Regulations, Chapter M-24, Section 414(2), June 16[th], 2010, last accessed 2018-03-04

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"Niels Konge says no to 'nanny-state' Yellowknife helmet law" CBC first posted May 27, 2014, last accessed 2018-03-05.
y. Town of Inuvik By-Law #2515/TR/11
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* Law not used in results presented.

Table 2:
Descriptive Statistics, NPHS and CCHS

Variable	Children (age 12 to 17)	Adults (age 18 to 64)
Rode a bike for leisure (past 3 months)	0.493	0.232
Minutes rode a bike	624.69	203.91
Minutes rode a bike, among cyclists	1267.77	880.29
How often wore a helmet, among cyclists:		
Always	34.24	36.97
Most of the time	15.36	7.3
Rarely	15.35	6.84
Never	35.05	48.89
Lives in a province that currently has an All-Age Helmet Law	0.176	0.180
Lives in a province that currently has a Youth Helmet Law	0.475	0.466
Female	0.500	0.505
Married	N.A.	0.523
High school or less	N.A.	0.317
Some university	N.A.	0.456
At least a BA	N.A.	0.227
Has any 0-5 year old children in the household	N.A.	0.165
Has any 6-11 year old children in the household	N.A.	0.174
12-17	100.0	0.0
18-35	0.0	0.379
36-54	0.0	0.447
55 and older	0.0	0.174
Observations	85,436	692,551

Weighted means, NPHS and CCHS, author calculations.

Table 3: Youth-Only and All-Age Helmet Laws Did Not Reduce Cycling and Increased Helmet Use Among Youths
Regression Adjusted Difference in Differences Models NPHS and CCHS 1994-2014, Youths Age 12-17

	(1) Any past 3 month cycling	(2) Any past 3 month cycling	(3) # minutes cycled past 3 months	(4) # minutes cycled past 3 months	(5) Always wears helmet, among cyclists	(6) Always wears helmet, among cyclists	(7) Always or most of the time wears helmet, among cyclists	(8) Always or most of the time wears helmet, among cyclists
Mean in 3 years prior	0.481	0.481	745.0	745.0	0.176	0.176	0.260	0.260
All-Age Helmet Law	0.0074	0.0154	-28.6	-27.3	0.278	0.316	0.292	0.322
	(0.799)	(0.690)	(0.710)	(0.772)	(0.000)**	(0.001)**	(0.000)**	(0.001)**
	[0.845]	[0.692]	[0.748]	[0.740]	[0.001]**	[0.000]**	[0.005]**	[0.012]*
	{0.828}	{0.692}	{0.774}	{0.773}	{0.003}**	{0.020}*	{0.009}**	{0.017}*
Percent Effect, All-Age Law	1.5	3.2	-3.8	-3.7	158.2	179.8	112.4	123.6
Mean in 3 years prior	0.496	0.496	618.4	618.4	0.239	0.239	0.385	0.385
Youth-Only Helmet Law	-0.0236	-0.0253	-51.65	-85.87	0.237	0.243	0.237	0.260
	(0.083)+	(0.128)	(0.338)	(0.157)	(0.000)**	(0.000)**	(0.000)**	(0.000)**
	[0.171]	[0.202]	[0.584]	[0.551]	[0.014]*	[0.035]*	[0.014]*	[0.021]*
	{0.165}	{0.199}	{0.580}	{0.538}	{0.009}**	{0.017}*	{0.012}*	{0.011}*
Percent effect, Youth Law	-4.8	-5.1	-8.4	-13.9	99.0	101.4	61.6	67.6
F-test								
All Age = Youth only	(0.194)	(0.174)	(0.749)	(0.544)	(0.410)	(0.234)	(0.298)	(0.351)
	[0.253]	[0.261]	[0.823]	[0.696]	[0.472]	[0.378]	[0.478]	[0.440]
	{0.252}	{0.247}	{0.802}	{0.668}	{0.483}	{0.392}	{0.470}	{0.453}
N	85,436	85,436	85,436	85,436	25,524	25,524	25,524	25,524
R-squared	0.168	0.169	0.112	0.113	0.152	0.153	0.191	0.192
Year dummies?	Y	Y	Y	Y	Y	Y	Y	Y
Province dummies?	Y	Y	Y	Y	Y	Y	Y	Y
Linear province trends?		Y		Y		Y		Y

Each entry represents a separate regression. Other variables in the models but not reported here include: a male dummy, age, race dummies, the provincial unemployment rate, month dummies, interviewed alone dummy, interviewed in person dummy, urban dummy, a dummy for presence of a graduated license program, and a dummy variable for the presence of a local bike-sharing program. P-values clustered on province in parenthesis, Wild-t bootstrap P-values with Rademacher weights in brackets and 6-Point weights in braces. + significant at 10%; * significant at 5%; ** significant at 1%.

Table 4: All-Age Helmet Laws Did Not Reduce Cycling and Increased Helmet Use Among Adults
Regression Adjusted Difference in Differences Models NPHS and CCHS 1994-2014, Adults Age 18-64

	(1) Any past 3 month cycling	(2) Any past 3 month cycling	(3) # minutes cycled past 3 months	(4) # minutes cycled past 3 months	(5) Always wears helmet, among cyclists	(6) Always wears helmet, among cyclists	(7) Always or most of the time wears helmet, among cyclists	(8) Always or most of the time wears helmet, among cyclists
Mean in 3 years prior	0.245	0.245	195.6	195.6	0.377	0.377	0.434	0.434
All-Age Helmet Law	-0.0062	-0.0159	14.96	-3.310	0.197	0.240	0.196	0.221
	(0.340)	(0.050)	(0.269)	(0.733)	(0.000)**	(0.000)**	(0.000)**	(0.000)**
	[0.454]	[0.210]	[0.335]	[0.805]	[0.007]**	[0.087]+	[0.007]**	[0.075]+
	{0.436}	{0.188}	{0.384}	{0.807}	{0.007}**	{0.045}*	{0.010}**	{0.028}*
Percent Effect	-2.5	-6.5	7.6	-1.7	52.2	63.7	45.1	50.8
Mean in 3 years prior	0.239	0.239	193.4	193.4	0.309	0.309	0.369	0.369
Youth-Only Helmet Law	-0.0129	-0.0089	-14.39	-7.531	0.0391	0.0212	0.0533	0.0244
	(0.077)+	(0.390)	(0.264)	(0.674)	(0.020)*	(0.110)	(0.001)**	(0.031)*
	[0.356]	[0.588]	[0.507]	[0.778]	[0.019]*	[0.321]	[0.045]*	[0.136]
	{0.402}	{0.628}	{0.529}	{0.787}	{0.045}*	{0.318}	{0.051}+	{0.147}
Percent effect	-5.4	-3.7	-7.4	-3.9	12.6	6.9	14.4	6.6
N	692,551	692,551	692,551	692,551	89,496	89,496	89,496	89,496
R-squared	0.089	0.089	0.037	0.037	0.144	0.145	0.152	0.153
Year dummies?	Y	Y	Y	Y	Y	Y	Y	Y
Province dummies?	Y	Y	Y	Y	Y	Y	Y	Y
Linear province trends?		Y		Y		Y		Y

Each entry represents a separate regression. Other variables in the models but not reported here include: a male dummy, age, education dummies, marital status dummies, race dummies, the provincial unemployment rate, month dummies, interviewed alone dummy, interviewed in person dummy, urban dummy, a dummy for presence of a graduated license program, and a dummy variable for the presence of a local bike-sharing program. P-values clustered on province in parenthesis, Wild-t bootstrap P-values with Rademacher weights in brackets and 6-Point weights in braces. + significant at 10%; * significant at 5%; ** significant at 1%.

Table 5: Effects of Helmet Laws on Youth Helmet Use Are Robust: Outcome is Always Wears Helmet, Among Cyclists Regression Adjusted Difference in Differences Models NPHS and CCHS 1994-2014, Youths Age 12-17

	(1) Baseline	(2) Control for Lead of Helmet Law	(3) Control for Lead of Helmet Law	(4) Drop Alberta	(5) Drop British Columbia	(6) Drop Ontario
Mean in 3 years prior	0.176	0.176	0.176	0.178	0.327	0.180
One Year Lead of All-Age Law		0.0326	0.0119			
		(0.811)	(0.923)			
		[0.840]	[0.914]			
All-Age Helmet Law	0.278	0.295	0.328	0.230	0.239	0.275
	(0.000)**	(0.003)**	(0.007)**	(0.001)**	(0.017)*	(0.002)**
	[0.001]**	[0.000]**	[0.002]**	[0.029]*	[0.020]*	[0.003]**
Percent effect, All-age law	158.2	167.6	186.2	129.4	73.1	152.8
Mean 3 years prior	0.239	0.239	0.239	0.155	0.239	0.262
One Year Lead of Youth Law		0.0765	0.0691			
		(0.000)**	(0.000)*			
		[0.008]**	[0.084]+			
Youth Helmet Law	0.237	0.265	0.274	0.193	0.237	0.257
	(0.000)**	(0.000)*	(0.000)*	(0.003)**	(0.000)**	(0.000)**
	[0.014]*	[0.011]*	[0.063]+	{0.096}+	[0.026]*	{0.001}**
Percent effect, Youth Law	99.0	111.0	114.7	124.5	99.1	98.3
N	25,524	25,524	25,524	21,385	24,168	12,645
R-squared	0.152	0.153	0.154	0.136	0.152	0.214
Year dummies?	Y	Y	Y	Y	Y	Y
Province dummies?	Y	Y	Y	Y	Y	Y
Linear province trends?			Y			

Each entry represents a separate regression. Other variables in the models but not reported here include: a male dummy, age dummies, education dummies, marital status dummies, race dummies, the provincial unemployment rate, month dummies, interviewed alone dummy, interviewed in person dummy, urban dummy, a dummy for presence of a graduated license program, and a dummy variable for the presence of a local bike-sharing program. P-values clustered on province in parenthesis and Wild-t bootstrap P-values with Rademacher weights in brackets. + significant at 10%; * significant at 5%; ** significant at 1%.

Table 6: Effects of Helmet Laws on Adult Helmet Use Are Robust: Outcome is Always Wears Helmet, Among Cyclists Regression Adjusted Difference in Differences Models NPHS and CCHS 1994-2014, Adults Age 18-64

	(1) Baseline	(2) Control for Lead of Helmet Law	(3) Control for Lead of Helmet Law	(4) Drop Alberta	(5) Drop British Columbia	(6) Drop Ontario
Mean in 3 years prior	0.377	0.377	0.377	0.372	0.330	0.370
One Year Lead of All-Age Law		0.0375	0.0040			
		(0.274)	(0.905)			
		[0.342]	[0.931]			
All-Age Helmet Law	0.197	0.219	0.245	0.191	0.221	0.174
	(0.000)**	(0.000)**	(0.001)**	(0.000)**	(0.000)**	(0.000)**
	[0.007]**	[0.015]*	[0.083]+	[0.061]+	[0.036]*	[0.003]**
Percent effect, All-Age Law	52.2	58.1	64.9	51.2	66.9	47.0
Mean 3 years prior	0.309	0.309	0.309	0.240	0.310	0.352
One Year Lead of Youth Law		0.0483	0.0274			
		(0.000)**	(0.015)*			
		[0.020]*	[0.273]			
Youth Helmet Law	0.0391	0.0557	0.0329	0.0144	0.0280	0.0592
	(0.020)*	(0.011)*	(0.096)+	(0.434)	(0.001)*	(0.086)+
	[0.019]*	[0.040]*	[0.379]	[0.458]	[0.009]**	[0.171]
Percent effect, Youth Law	12.6	18.0	10.6	6.0	9.0	16.8
N	89,496	89,496	89,496	74,484	83,670	46,659
R-squared	0.144	0.144	0.145	0.151	0.120	0.184
Year dummies?	Y	Y	Y	Y	Y	Y
Province dummies?	Y	Y	Y	Y	Y	Y
Linear province trends?			Y			

Each entry represents a separate regression. Other variables in the models but not reported here include: a male dummy, age dummies, education dummies, marital status dummies, race dummies, the provincial unemployment rate, month dummies, interviewed alone dummy, interviewed in person dummy, urban dummy, a dummy for presence of a graduated license program, and a dummy variable for the presence of a local bike-sharing program. P-values clustered on province in parenthesis and Wild-t bootstrap P-values with Rademacher weights in brackets. + significant at 10%; * significant at 5%; ** significant at 1%.

Table 7: Heterogeneity in Effects of Helmet Laws on Youth Helmet Use: Outcome is Always Wears Helmet, Among Cyclists Regression Adjusted Difference in Differences Models, Youths Age 12-17

	(1) Males	(2) Females	(3) Urban	(4) Rural	(5) Oct-Mar	(6) Apr-Sep
Mean 3 yrs prior	0.160	0.200	0.141	0.239	0.314	0.079
All-Age Law	0.287	0.277	0.315	0.186	0.223	0.317
	(0.003)**	(0.001)**	(0.000)**	(0.001)**	(0.004)**	(0.000)**
	[0.019]*	[0.000]**	[0.002]**	[0.001]**	[0.001]**	[0.000]**
Percent effect, All-Age Law	179.2	138.4	223.3	77.9	71.3	399.1
Mean 3 yrs prior	0.227	0.255	0.266	0.122	0.228	0.247
Youth Law	0.235	0.240	0.240	0.256	0.263	0.211
	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**
	[0.014]*	[0.018]*	[0.016]*	[0.009]**	[0.019]*	[0.019]*
Percent effect, Youth Law	103.5	94.1	90.0	209.4	115.1	85.5
N	14,974	10,550	18,495	7,029	10,532	14,992
R-squared	0.152	0.160	0.160	0.134	0.151	0.158
Year dummies?	Y	Y	Y	Y	Y	Y
Province dummies?	Y	Y	Y	Y	Y	Y

Each entry represents a separate regression. Other variables in the models but not reported here include: a male dummy, age dummies, education dummies, marital status dummies, race dummies, the provincial unemployment rate, month dummies, interviewed alone dummy, interviewed in person dummy, urban dummy, a dummy for presence of a graduated license program, and a dummy variable for the presence of a local bike-sharing program. P-values clustered on province in parenthesis and Wild-t bootstrap P-values with Rademacher weights in brackets. + significant at 10%; * significant at 5%; ** significant at 1%.

Table 8: Heterogeneity in Effects of Helmet Laws on Adult Helmet Use: Outcome is Always Wears Helmet, Among Cyclists Regression Adjusted Difference in Differences Models, Adults Age 18-64

	(1) 18-35	(2) 36-64	(3) Males	(4) Females	(5) >=BA (Age 25-64)	(6) Post Sec.<BA (Age 25-64)	(7) HS or < (Age 25-64)	(8) Urban	(9) Rural	(10) Oct-Mar	(11) Apr-Sep
Mean 3 yrs prior	0.329	0.429	0.361	0.398	0.600	0.446	0.231	0.398	0.298	0.319	0.392
All-Age Law	0.212	0.177	0.194	0.207	0.084	0.197	0.228	0.191	0.195	0.242	0.165
	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.021)*	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**
	[0.019]*	[0.003]**	[0.017]*	[0.001]**	[0.119]	[0.009]**	[0.020]*	[0.029]*	[0.001]**	[0.031]*	[0.001]**
Percent effect, All-Age Law	64.3	41.1	53.6	52.0	14.0	44.2	98.7	48.0	65.4	75.7	42.2
Mean 3 yrs prior	0.264	0.358	0.296	0.328	0.516	0.309	0.201	0.330	0.143	0.326	0.299
Youth Law	0.0676	0.0139	0.0373	0.0431	-0.0232	0.0436	0.0417	0.0345	0.0537	0.0760	0.0120
	(0.019)*	(0.055)+	(0.018)*	(0.071)+	(0.130)	(0.087)+	(0.084)+	(0.038)*	(0.027)*	(0.030)*	(0.198)
	[0.079]+	[0.019]*	[0.021]*	[0.189]	[0.256]	[0.285]	[0.326]	[0.034]*	[0.258]	[0.089]+	[0.380]
Percent effect, Youth Law	25.6	3.9	12.6	13.1	-4.5	14.1	20.8	10.5	37.5	23.3	4.0
N	39,956	49,540	48,159	41,337	21,381	33,995	18,155	69,703	19,793	35,040	54,456
R-squared	0.133	0.137	0.146	0.139	0.077	0.091	0.097	0.140	0.141	0.143	0.145
Year dummies?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Province dummies?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Each entry represents a separate regression. Other variables in the models but not reported here include: a male dummy, age dummies, education dummies, marital status dummies, race dummies, the provincial unemployment rate, month dummies, interviewed alone dummy, interviewed in person dummy, urban dummy, a dummy for presence of a graduated license program, and a dummy variable for the presence of a local bike-sharing program. P-values clustered on province in parenthesis and Wild-t bootstrap P-values with Rademacher weights in brackets. + significant at 10%; * significant at 5%; ** significant at 1%.

Table 9: Youth Helmet Laws Associated with General Reduction in Exercise Participation but No Effect on Weight, Youths Regression Adjusted Difference in Differences Models, Youths Age 12-17

	(1) Any past 3 month walking for exercise	(2) # minutes walking for exercise	(3) Any past 3 month jogging for exercise	(4) # minutes jogging for exercise	(5) Any past 3 month home exercise	(6) # minutes home exercise	(7) Body Mass Index
Mean 3 years prior	0.640	977.1	0.532	382.7	0.409	417.5	21.6
All-Age Law	-0.0076	-79.89	-0.0287	9.556	-0.0499	-36.19	-0.0072
	(0.769)	(0.441)	(0.146)	(0.869)	(0.263)	(0.209)	(0.949)
	[0.740]	[0.620]	[0.159]	[0.876]	[0.330]	[0.330]	[0.947]
Percent effect, All-Age Law	-1.2	-8.2	-5.4	2.5	-12.2	-8.7	0.0
Mean 3 years prior	0.671	853.3	0.572	422.0	0.410	446.4	21.3
Youth Law	-0.0420	-41.02	-0.0448	-23.00	-0.0591	-52.72	0.0130
	(0.001)**	(0.252)	(0.003)*	(0.198)	(0.009)**	(0.141)	(0.848)
	[0.050]*	[0.407]	[0.095]+	[0.318]	[0.0139]*	[0.556]	[0.871]
Percent effect, Youth Law	-6.3	-4.8	-7.8	-5.4	-14.4	-11.8	0.1
N	85,436	84,542	85,436	84,757	85,436	85,005	79,604
R-squared	0.066	0.027	0.058	0.022	0.034	0.025	0.079
Year dummies?	Y	Y	Y	Y	Y	Y	Y
Province dummies?	Y	Y	Y	Y	Y	Y	Y

Each entry represents a separate regression. Other variables in the models but not reported here include: a male dummy, age dummies, education dummies, marital status dummies, race dummies, the provincial unemployment rate, month dummies, interviewed alone dummy, interviewed in person dummy, urban dummy, a dummy for presence of a graduated license program, and a dummy variable for the presence of a local bike-sharing program. P-values clustered on province in parenthesis and Wild-t bootstrap P-values with Rademacher weights in brackets. + significant at 10%; * significant at 5%; ** significant at 1%.

Table 10: Helmet Laws Induced Substitution Toward Home Exercise in Winter, Adults
Regression Adjusted Difference in Differences Models, Adults Age 18-64

	(1) # minutes cycled, Oct-Mar	(2) # minutes cycled, Apr-Sep	(3) # minutes walking, Oct-Mar	(4) # minutes walking, Apr-Sep	(5) # minutes jogging, Oct-Mar	(6) # minutes jogging, Apr-Sep	(7) # minutes home exercise, Oct-Mar	(8) # minutes home exercise, Apr-Sep	(9) Body Mass Index, Oct-Mar	(10) Body Mass Index, Apr-Sep
Mean 3 yrs prior	134.8	224.6	1067.4	1329.0	156.6	144.0	294.3	317.6	26.09	25.59
All-Age Law	-15.26	37.68	26.19	84.08	5.953	26.95	43.10	-11.59	-0.0739	-0.333
	(0.083)+	(0.149)	(0.667)	(0.187)	(0.745)	(0.003)**	(0.004)**	(0.488)	(0.374)	(0.003)**
	[0.099]+	[0.281]	[0.777]	[0.417]	[0.727]	[0.009]**	[0.095]+	[0.498]	[0.444]	[0.095]+
Percent effect, All-Age Law	-11.3	16.8	2.5	6.3	3.8	18.7	14.6	-3.6	-0.3	-1.3
Mean 3 yrs prior	137.5	244.2	1015. 4	1196.9	158.5	153.0	391.3	343.8	25.9	26.0
Youth Law	-16.72	-10.10	20.43	-4.196	0.562	11.92	-25.92	16.13	0.119	-0.0874
	(0.399)	(0.268)	(0.455)	(0.764)	(0.915)	(0.104)	(0.009)**	(0.082)+	(0.376)	(0.285)
	[0.607]	[0.394]	[0.478]	[0.722]	[0.913]	[0.583]	[0.438]	[0.438]	[0.827]	[0.506]
Percent effect, Youth Law	-12.2	-4.1	2.0	-0.4	0.4	7.8	-6.6	4.7	0.5	-0.3
N	322,711	369,840	321,050	368,064	322,378	369,442	321,907	369,016	310,866	356,593
R-squared	0.036	0.034	0.027	0.024	0.042	0.046	0.018	0.017	0.093	0.091
Year dummies?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Prov dummies?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Each entry represents a separate regression. Other variables in the models but not reported here include: a male dummy, age dummies, education dummies, marital status dummies, race dummies, the provincial unemployment rate, month dummies, interviewed alone dummy, interviewed in person dummy, urban dummy, a dummy for presence of a graduated license program, and a dummy variable for the presence of a local bike-sharing program. P-values clustered on province in parenthesis and Wild-t bootstrap P-values with Rademacher weights in brackets. + significant at 10%; * significant at 5%; ** significant at 1%.

Table 11: Evidence on Role Model Effects of Helmet Laws on Adult Helmet Use, by Presence of Children in Household
Regression Adjusted Difference in Differences Models NPHS and CCHS 1994-2014, Adults Age 25-50

	(1) All adults in this age group (25-50)	(2) No kids age 0-11 in HH	(3) Any kids age 0-11 in HH	(4) Any kids age 0-5 in HH	(5) Any kids age 6-11 in HH	(6) Any kids age 0-11 in HH, male respondent (likely fathers)	(7) Any kids age 0-11 in HH, female respondent (likely mothers)
Mean in 3 years prior	0.450	0.449	0.451	0.450	0.403	0.500	0.393
All-Age Helmet Law	0.166	0.143	0.189	0.184	0.208	0.168	0.206
	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**
	[0.011]*	[0.043]*	[0.001]**	[0.003]**	[0.005]**	[0.009]**	[0.002]**
Percent effect, All-Age Law	36.9	31.9	42.0	40.8	51.6	33.7	52.3
Mean 3 years prior	0.349	0.314	0.389	0.402	0.398	0.371	0.407
Youth Helmet Law	0.0362	0.0342	0.0407	0.0696	0.0034	0.0560	0.0236
	(0.002)**	(0.049)*	(0.004)**	(0.024)*	(0.894)	(0.001)**	(0.207)
Percent effect, Youth Law	10.4	10.9	10.5	17.3	0.9	15.1	5.8
N	54,651	29,203	25,448	14,678	17,704	12,426	13,022
R-squared	0.137	0.132	0.148	0.153	0.146	0.153	0.147
Province dummies?	Y	Y	Y	Y	Y	Y	Y
Year dummies?	Y	Y	Y	Y	Y	Y	Y

Each entry represents a separate regression. Other variables in the models but not reported here include: a male dummy, age dummies, education dummies, marital status dummies, race dummies, the provincial unemployment rate, month dummies, interviewed alone dummy, interviewed in person dummy, urban dummy, a dummy for presence of a graduated license program, and a dummy variable for the presence of a local bike-sharing program. P-values clustered on province in parenthesis and Wild-t bootstrap P-values with Rademacher weights in brackets. + significant at 10%; * significant at 5%; ** significant at 1%.

Appendix Table 1: Youth-Only and All-Age Helmet Laws Did Not Reduce Cycling and Increased Helmet Use Among Youths Regression Adjusted Difference in Differences Models NPHS and CCHS 1994-2014, Youths Age 12-17 Full Helmet module sample

	(1) Any past 3 month cycling, Helmet module	(2) Any past 3 month cycling, Helmet module	(3) # minutes cycled past 3 months, Helmet module	(4) # minutes cycled past 3 months, Helmet module	(5) Always wears helmet, population	(6) Always wears helmet, population	(7) Always or most of the time wears helmet, population	(8) Always or most of the time wears helmet, population
Mean in 3 years prior	0.485	0.485	759.5	759.5	0.094	0.094	0.139	0.139
All-Age Helmet Law	0.0283	0.0703	-32.94	-47.95	0.142	0.190	0.151	0.203
	(0.430)	(0.313)	(0.704)	(0.693)	(0.013)*	(0.015)*	(0.018)*	(0.028)*
	[0.471]	[0.452]	[0.743]	[0.706]	[0.007]**	[0.006]**	[0.033]*	[0.026]*
Percent Effect, All-Age Law	5.8	14.5	-4.3	-6.3	150.9	201.8	108.2	145.6
Mean in 3 years prior	0.508	0.508	659.3	659.3	0.129	0.129	0.207	0.207
Youth-Only Helmet Law	-0.0247	-0.0168	-42.12	-78.44	0.101	0.114	0.0959	0.119
	(0.167)	(0.348)	(0.398)	(0.193)	(0.000)**	(0.000)**	(0.001)**	(0.000)**
	[0.237]	[0.332]	[0.582]	[0.486]	[0.017]*	[0.037]*	[0.014]*	[0.034]*
Percent effect, Youth Law	-4.9	-3.3	-6.4	-11.9	78.6	88.8	46.3	57.4
F-test								
All Age = Youth only	(0.040)*	(0.115)	(0.901)	(0.770)	(0.327)	(0.202)	(0.236)	(0.248)
	[0.208]	[0.298]	[0.927]	[0.803]	[0.463]	[0.359]	[0.439]	[0.402]
N	48,322	48,322	48,322	48,322	48,322	48,322	48,322	48,322
R-squared	0.166	0.167	0.109	0.110	0.102	0.104	0.133	0.135
Year dummies?	Y	Y	Y	Y	Y	Y	Y	Y
Province dummies?	Y	Y	Y	Y	Y	Y	Y	Y
Linear province trends?		Y		Y		Y		Y

Each entry represents a separate regression. Other variables in the models but not reported here include: a male dummy, age, race dummies, the provincial unemployment rate, month dummies, interviewed alone dummy, interviewed in person dummy, urban dummy, a dummy for presence of a graduated license program, and a dummy variable for the presence of a local bike-sharing program. P-values clustered on province in parenthesis and Wild-t bootstrap P-values with Rademacher weights in brackets. $^{+}$ significant at 10%; * significant at 5%; ** significant at 1%.

Appendix Table 2: All-Age Helmet Laws Did Not Reduce Cycling and Increased Helmet Use Among Adults
Regression Adjusted Difference in Differences Models NPHS and CCHS 1994-2014, Adults Age 18-64
Full Helmet Module Sample

	(1) Any past 3 month cycling, Helmet module	(2) Any past 3 month cycling, Helmet module	(3) # minutes cycled past 3 months, Helmet module	(4) # minutes cycled past 3 months, Helmet module	(5) Always wears helmet, population	(6) Always wears helmet, population	(7) Always or most of the time wears helmet, population	(8) Always or most of the time wears helmet, population
Mean in 3 years prior	0.255	0.255	202.6	202.6	0.101	0.101	0.116	0.116
All-Age Helmet Law	0.0040	0.0079	34.53	20.35	0.0334	0.0354	0.0326	0.0310
	(0.517)	(0.526)	(0.029)*	(0.231)	(0.001)**	(0.010)**	(0.001)**	(0.009)**
	[0.464]	[0.626]	[0.133]	[0.354]	[0.013]*	[0.036]*	[0.007]**	[0.026]*
Percent Effect, All-Age Law	1.6	3.1	17.0	10.0	33.0	35.0	28.0	26.7
Mean in 3 years prior	0.235	0.235	189.2	189.2	0.076	0.076	0.090	0.090
Youth-Only Helmet Law	-0.0144	-0.0100	-10.84	5.251	0.0002	0.0005	0.0023	0.0002
	(0.027)*	(0.220)	(0.284)	(0.671)	(0.952)	(0.900)	(0.277)	(0.941)
	[0.262]	[0.405]	[0.498]	[0.680]	[0.965]	[0.921]	[0.237]	[0.956]
Percent effect, Youth Law	-6.1	-4.3	-5.7	2.8	0.2	0.6	2.5	0.2
N	392,677	392,677	392,677	392,677	392,677	392,677	392,677	392,677
R-squared	0.091	0.091	0.036	0.036	0.053	0.053	0.059	0.059
Year dummies?	Y	Y	Y	Y	Y	Y	Y	Y
Province dummies?	Y	Y	Y	Y	Y	Y	Y	Y
Linear province trends?		Y		Y		Y		Y

Each entry represents a separate regression. Other variables in the models but not reported here include: a male dummy, age, education dummies, marital status dummies, race dummies, the provincial unemployment rate, month dummies, interviewed alone dummy, interviewed in person dummy, urban dummy, a dummy for presence of a graduated license program, and a dummy variable for the presence of a local bike-sharing program. P-values clustered on province in parenthesis and Wild-t bootstrap P-values with Rademacher weights in brackets. + significant at 10%; * significant at 5%; ** significant at 1%.

Appendix Table 3: Robustness of Helmet Law Effects on Any Past 3 Month Cycling, Youths
Regression Adjusted Difference in Differences Models NPHS and CCHS 1994-2014, Youths Age 12-17

	(1) Baseline	(2) Control for Lead of Law	(3) Control for Lead of Law	(4) Drop Alberta	(5) Drop British Columbia	(6) Drop Ontario
Mean in 3 years prior	0.481	0.481	0.481	0.482	0.419	0.485
One Year Lead of All-Age Law		-0.0299	-0.0458			
		(0.234)	(0.157)			
		[0.356]	[0.317]			
All-Age Helmet Law	0.0074	-0.0035	0.0001	-0.00539	-0.0058	0.0074
	(0.799)	(0.901)	(0.997)	(0.851)	(0.865)	(0.814)
	[0.845]	[0.930]	[0.999]	[0.863]	[0.839]	[0.855]
Percent effect, All-Age Law	1.5	-0.7	0.0	-1.1	-1.4	1.5
Mean 3 years prior	0.496	0.496	0.496	0.487	0.496	0.481
One Year Lead of Youth Law		-0.0548	-0.0427			
		(0.049)*	(0.080)+			
		[0.361]	[0.410]			
Youth Helmet Law	-0.0236	-0.0418	-0.0434	-0.0520	-0.0348	-0.0178
	(0.083)+	(0.013)*	(0.014)*	(0.001)**	(0.000)**	(0.166)
	[0.171]	[0.122]	[0.107]	[0.136]	[0.095]+	[0.330]
Percent effect, Youth Law	-4.8	-8.4	-8.7	-10.7	-7.0	-3.7
N	85,436	85,436	85,436	76,154	76,306	56,608
R-squared	0.168	0.168	0.169	0.172	0.186	0.171
Year dummies?	Y	Y	Y	Y	Y	Y
Province dummies?	Y	Y	Y	Y	Y	Y
Linear province trends?			Y			

Each entry represents a separate regression. Other variables in the models but not reported here include: a male dummy, age dummies, education dummies, marital status dummies, race dummies, the provincial unemployment rate, month dummies, interviewed alone dummy, interviewed in person dummy, urban dummy, a dummy for presence of a graduated license program, and a dummy variable for the presence of a local bike-sharing program. P-values clustered on province in parenthesis and Wild-t bootstrap P-values with Rademacher weights in brackets. $^{+}$ significant at 10%; * significant at 5%; ** significant at 1%.

Appendix Table 4: Robustness of Helmet Law Effects on Any Past 3 Month Cycling, Youths
Regression Adjusted Difference in Differences Models NPHS and CCHS 1994-2014, Adults Age 18-64

	(1) Baseline	(2) Control for Lead of Law	(3) Control for Lead of Law	(4) Drop Alberta	(5) Drop British Columbia	(6) Drop Ontario
Mean in 3 years prior	0.245	0.245	0.245	0.242	0.153	0.239
One Year Lead of All-Age Law		-0.0089	-0.0102			
		(0.432)	(0.425)			
		[0.490]	[0.526]			
All-Age Helmet Law	-0.0062	-0.0103	-0.0202	-0.0066	0.0006	-0.0067
	(0.340)	(0.324)	(0.092)+	(0.378)	(0.949)	(0.432)
	[0.454]	[0.454]	[0.337]	[0.492]	[0.947]	[0.496]
Percent effect, All-Age Law	-2.5	-4.2	-8.2	-2.7	0.4	-2.8
Mean 3 years prior	0.239	0.239	0.239	0.250	0.239	0.240
One Year Lead of Youth Law		-0.0164	-0.0094			
		(0.128)	(0.369)			
		[0.570]	[0.790]			
Youth Helmet Law	-0.0129	-0.0180	-0.0129	0.0042	-0.0177	-0.0145
	(0.077)+	(0.058)+	(0.294)	(0.579)	(0.013)*	(0.023)*
	[0.356]	[0.584]	[0.797]	[0.714]	[0.312]	[0.388]
Percent effect, Youth Law	-5.4	-7.5	-5.4	1.7	-7.4	-6.0
N	692,551	692,551	692,551	618,914	615,505	459,051
R-squared	0.089	0.089	0.089	0.090	0.095	0.093
Year dummies?	Y	Y	Y	Y	Y	Y
Province dummies?	Y	Y	Y	Y	Y	Y
Linear province trends?			Y			

Each entry represents a separate regression. Other variables in the models but not reported here include: a male dummy, age dummies, education dummies, marital status dummies, race dummies, the provincial unemployment rate, month dummies, interviewed alone dummy, interviewed in person dummy, urban dummy, a dummy for presence of a graduated license program, and a dummy variable for the presence of a local bike-sharing program. P-values clustered on province in parenthesis and Wild-t bootstrap P-values with Rademacher weights in brackets. + significant at 10%; * significant at 5%; ** significant at 1%.

Appendix Table 5: Heterogeneity in Effects of Helmet Laws on Youth Cycling
Regression Adjusted Difference in Differences Models, Youths Age 12-17
Outcome is Any Past 3 Month Cycling

	(1) Males	(2) Females	(3) Urban	(4) Rural	(5) Oct-Mar	(6) Apr-Sep
Mean 3 yrs prior	0.573	0.382	0.459	0.522	0.428	0.524
All-Age Law	-0.0038	0.0100	0.0260	-0.0273	-0.0106	0.0166
	(0.930)	(0.670)	(0.443)	(0.339)	(0.671)	(0.665)
	[0.906]	[0.700]	[0.490]	[0.452]	[0.817]	[0.691]
	{0.926}	{0.709}	{0.504}	{0.462}	{0.805}	{0.702}
Percent effect, All-Age Law	-0.7	2.6	5.7	-5.2	-2.5	3.2
Mean 3 yrs prior	0.567	0.423	0.490	0.520	0.443	0.556
Youth Law	-0.0120	-0.0356	-0.0202	-0.0198	-0.0353	-0.0118
	(0.616)	(0.060)+	(0.299)	(0.255)	(0.064)+	(0.475)
	[0.678]	[0.276]	[0.346]	[0.862]	[0.217]	[0.517]
Percent effect, Youth Law	-2.1	-8.4	-4.1	-3.8	-8.0	-2.1
N	43,305	42,131	61,645	23,791	40,671	44,765
R-squared	0.153	0.143	0.159	0.209	0.170	0.123
Year dummies?	Y	Y	Y	Y	Y	Y
Province dummies?	Y	Y	Y	Y	Y	Y

Each entry represents a separate regression. Other variables in the models but not reported here include: a male dummy, age dummies, education dummies, marital status dummies, race dummies, the provincial unemployment rate, month dummies, interviewed alone dummy, interviewed in person dummy, urban dummy, a dummy for presence of a graduated license program, and a dummy variable for the presence of a local bike-sharing program. P-values clustered on province in parenthesis and Wild-t bootstrap P-values with Rademacher weights in brackets. + significant at 10%; * significant at 5%; ** significant at 1%.

Appendix Table 6: Heterogeneity in the Effects of Helmet Laws on Adult Cycling
Regression Adjusted Difference in Differences Models, Adults Age 18-64

	(1) 18-35	(2) 36-64	(3) Males	(4) Females	(5) >=BA (Age 25-64)	(6) Post Sec.< BA (Age 25-64)	(7) HS or < (Age 25-64)	(8) Urban	(9) Rural	(10) Oct-Mar	(11) Apr-Sep
Mean 3 years prior	0.322	0.196	0.290	0.203	0.346	0.242	0.144	0.263	0.190	0.178	0.276
All-Age Law	-0.0107	-0.0040	-0.0174	0.0040	-0.0212	0.0028	0.0100	-0.0115	0.0124	-0.0197	-0.0011
	(0.194)	(0.750)	(0.319)	(0.679)	(0.087)+	(0.801)	(0.316)	(0.094)+	(0.223)	(0.051)+	(0.928)
	[0.215]	[0.852]	[0.665]	[0.670]	[0.262]	[0.831]	[0.347]	[0.285]	[0.322]	[0.071]+	[0.933]
Percent effect, All-Age Law	-3.3	-2.0	-6.0	2.0	-6.1	1.2	7.0	-4.4	6.5	-11.1	-0.4
Mean 3 years prior	0.285	0.206	0.276	0.204	0.305	0.231	0.171	0.245	0.204	0.195	0.279
Youth Law	-0.0150	-0.0109	-0.0258	0.0006	-0.0150	-0.0177	-0.0027	-0.0198	0.0196	-0.0160	-0.0087
	(0.224)	(0.009)**	(0.023)*	(0.878)	(0.023)*	(0.039)*	(0.759)	(0.032)*	(0.049)*	(0.268)	(0.170)
	[0.486]	[0.190]	[0.334]	[0.889]	[0.150]	[0.310]	[0.858]	[0.378]	[0.294]	[0.554]	[0.340]
Percent effect, Youth Law	-5.3	-5.3	-9.3	0.3	-4.9	-7.7	-1.6	-8.1	9.6	-8.2	-3.1
N	244,473	448,078	319,374	373,177	128,025	279,510	198,912	513,604	178,947	322,711	369,840
R-squared	0.077	0.093	0.086	0.081	0.094	0.077	0.075	0.089	0.092	0.089	0.077
Province dummies?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year dummies?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Each entry represents a separate regression. Other variables in the models but not reported here include: a male dummy, age dummies, education dummies, marital status dummies, race dummies, the provincial unemployment rate, month dummies, interviewed alone dummy, interviewed in person dummy, urban dummy, a dummy for presence of a graduated license program, and a dummy variable for the presence of a local bike-sharing program. P-values clustered on province in parenthesis and Wild-t bootstrap P-values with Rademacher weights in brackets. + significant at 10%; * significant at 5%; ** significant at 1%.

Appendix Table 7: Evidence on Role Model Effects of Helmet Laws on Adult Cycling, by Presence of Children in Household
Regression Adjusted Difference in Differences Models NPHS and CCHS 1994-2014, Adults Age 25-50

	(1) All adults in this age group (25-50)	(2) No kids age 0-11 in HH	(3) Any kids age 0-11 in HH	(4) Any kids age 0-5 in HH	(5) Any kids age 6-11 in HH	(6) Any kids age 0-11 in HH, male respondent (fathers)	(7) Any kids age 0-11 in HH, female respondent (mothers)
Mean in 3 years prior	0.273	0.252	0.297	0.275	0.331	0.358	0.247
All-Age Helmet Law	-0.0011	0.0000	0.0004	0.0089	-0.0189	-0.0116	0.0107
	(0.902)	(0.998)	(0.981)	(0.492)	(0.341)	(0.685)	(0.451)
	[0.927]	[0.998]	[0.975]	[0.518]	[0.560]	[0.901]	[0.475]
Percent effect, All-Age Law	-0.4	0.0	0.1	3.2	-5.7	-3.2	4.3
Mean 3 years prior	0.253	0.241	0.268	0.248	0.293	0.290	0.250
Youth Helmet Law	-0.0114	-0.0119	-0.0097	-0.0056	-0.0188	-0.0232	0.0027
	(0.103)	(0.145)	(0.040)*	(0.418)	(0.001)**	(0.008)**	(0.602)
	[0.419]	[0.496]	[0.220]	[0.446]	[0.019]*	[0.086]+	[0.596]
Percent effect, Youth Law	-4.5	-5.0	-3.6	-2.3	-6.4	-8.0	1.1
N	385,777	224,647	161,130	100,026	101,251	67,341	93,789
R-squared	0.088	0.080	0.110	0.100	0.125	0.110	0.102
Province dummies?	Y	Y	Y	Y	Y	Y	Y
Year dummies?	Y	Y	Y	Y	Y	Y	Y

Each entry represents a separate regression. Other variables in the models but not reported here include: a male dummy, age dummies, education dummies, marital status dummies, race dummies, the provincial unemployment rate, month dummies, interviewed alone dummy, interviewed in person dummy, urban dummy, a dummy for presence of a graduated license program, and a dummy variable for the presence of a local bike-sharing program. P-values clustered on province in parenthesis and Wild-t bootstrap P-values with Rademacher weights in brackets. + significant at 10%; * significant at 5%; ** significant at 1%.