Health Care Cost of Smoking in Ontario, 2003 to 2041

July 2018

The Ottawa Hospital
L'Hôpital d'Ottawa

ICES

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About the Organizations Involved in This Report

The Institute for Clinical Evaluative Sciences

As an independent not-for-profit corporation, the Institute for Clinical Evaluative Sciences (ICES) serves as a trusted and impartial source of high-quality research that influences the design, implementation and evaluation of health policy and the delivery of health care. ICES' unbiased evidence provides a clearer understanding of the shifting health care needs of Ontarians and a stimulus for discussion of practical solutions to optimize scarce resources.

Key to ICES' work is its ability to link population-based health information, at the patient level, in a way that ensures the privacy and confidentiality of personal health information. Linked databases reflecting 13 million of 34 million Canadians allow researchers to follow patient populations through diagnosis and treatment, and to evaluate outcomes.

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The Ottawa Hospital is one of Canada's largest learning and research hospitals with over 1,100 beds, approximately 12,000 staff and an annual budget of over $1.2 billion. Our focus on research and learning helps us develop new and innovative ways to treat patients and improve care. As a multi-campus hospital, affiliated with the University of Ottawa, we deliver specialized care to the Eastern Ontario region, but our techniques and research discoveries are adopted around the world. We engage the community at all levels to support our vision for better patient care. See **www.ohri.ca** for more information about research at The Ottawa Hospital.

List of Exhibits

Appendix

Summary

What do we know?

Previous research conducted at the Institute for Clinical Evaluative Sciences (ICES) examined the impact of smoking, unhealthy alcohol consumption, poor diet and physical inactivity on health care costs in Ontario and found that improvement in these behaviours resulted in a $4.9 billion decrease in health care expenditure in the 10 years from 2004 to 2013; smoking cessation accounted for 84% of this reduction.

What does this report tell us?

Health care expenditures attributable to smoking are projected to decrease through to 2041. However, because the health effects of smoking persist long after people quit, there will still be significant health care expenditures for decades to come.

- Among current smokers aged 20 and older, smoking prevalence is projected to decline to single digits (less than 10% of the population) by 2023 for women and by 2040 for men. The prevalence of former smokers will take considerably longer to reach single digits.
- Differences in smoking prevalence across sociodemographic position are large and persist throughout the entire 38 years of the study (2003 to 2041).
- Cumulatively from 2003 to 2041, there will be an estimated $51-billion reduction in smoking-attributable health care expenditures.
- Despite this reduction, smoking-attributable health care expenditures will amount to $164 billion between 2003 and 2041.

Where do we go from here?

Patients First: Action Plan for Health Care—Ontario's updated strategy for improving the province's health system—outlines a number of objectives whose effect on future health care expenditures has not been similarly evaluated.

We anticipate that evaluations of most other health strategies, in particular "down stream" health care strategies, will not demonstrate as large a role for a sustainable health care system as smoking prevention and other strategies to improve health behaviours and strengthen sociodemographic conditions.

Background

Smoking is a leading cause of preventable morbidity and mortality worldwide.[1] This situation is mirrored in Canada where smoking-attributable mortality increased between 2002 and 2012, and in 2012, more than 45,000 deaths were attributable to smoking and the direct health care costs of tobacco use were estimated to be $6.5 billion.[2]

Previously, our research team at ICES examined the impact of four health behaviours (smoking, unhealthy alcohol consumption, poor diet and physical inactivity) and sociodemographic position on health care costs.[3] That report, which had a look-back window of 10 years (from 2004 to 2013), was the first to directly measure how changes in the four health behaviours resulted in changes in health care expenditure. Overall, improvement in Ontarians' health behaviours resulted in a $4.9 billion decrease in health care expenditure; most of this reduction (84%) came from smoking cessation. Nevertheless, health behaviours and sociodemographic position still took a hefty toll, accounting for a burden of $134 billion in health care costs over the 10 years.

Given the impact of declining smoking prevalence and known disparities in health behaviours across sociodemographic groups, Ontario policy makers and public health practitioners are interested in the future effect of current policies on the health of Ontarians. This study is in response to requests* to further examine the impact of smoking reduction policies on future smoking prevalence, as well as the potential economic and health equity impacts of preventive strategies.

* These requests were submitted through the Applied Health Research Question (AHRQ) initiative of the Ontario Ministry of Health and Long-Term Care by a health-system policy maker or care provider seeking research evidence that will inform planning, policy and program development for the benefit the entire Ontario health system.

We examined the following questions:

- What is the historic and future projected prevalence of smoking in Ontario?
- Given projections of smoking prevalence, what are the future smoking-attributable health care expenditures?
- What impact will smoking trends have on gaps in health among sociodemographic groups?

Patients First: Action Plan for Health Care is Ontario's updated strategy for improving the province's health system.[4] *Patients First* highlights the importance of health promotion in each of its four key objectives. For this report, two objectives are particularly noteworthy:

- creating a culture of health and wellness within the "Inform: Support people and patients" objective;
- making evidence-based decisions predicated on value and quality to sustain the system for generations to come within the "Protect: Protect our universal health care system" objective.

Methods

This report estimated smoking-attributable health care expenditures from 2003 to 2041. The analyses were performed in five steps.

Step 1 – Estimate smoking prevalence, including historic trends from 1960 to 2013 and future projections from 2014 to 2041.

Step 2 – Estimate the smoking-attributable fraction of health care expenditures from 2003 to 2041.

Step 3 – Project health care expenditures from 2017 to 2041.

Step 4 – Estimate smoking-attributable health care expenditures from 2003 to 2041.

Step 5 – Describe how smoking-attributable health care expenditures vary among sociodemographic groups.

Base Population

The population of interest is Ontario men and women aged 20 or older in the years from 1960 to 2041. The report's focus on this age group is a reflection of the age at which smoking-attributable health care costs could be expected to increase. This population is estimated annually using the Statistics Canada Population Health Model (POHEM).[5] The initiation and cessation models, and consequently the current and former prevalence estimates, were generated using those individuals who were residents of Ontario in each year under consideration.

Data Sources

Smoking prevalence

We generated estimates of smoking prevalence using the Ontario sample from multiple cycles of the Canadian Community Health Survey (CCHS), including Cycle 2.1 (2003), Cycle 3.1 (2005), Cycle 4.1 (2007) and annual cycles from 2009 to 2014. The CCHS is a cross-sectional survey conducted by Statistics Canada that collects data related to health determinants, health status and health care use. The survey employs a complex, multistage sampling strategy to randomly select households in each health region. Individuals in each household are automatically selected to participate in the survey using various selection probabilities based on age and household composition. A weight is assigned to each respondent signifying the number of individuals that the respondent represents in the target population. The target population includes individuals aged 12 and older living in Canada's 10 provinces and three territories. Excluded from the survey coverage are individuals living on First Nations reserves, institutionalized individuals, full-time members of the Canadian Forces and residents of certain remote areas.

Health care expenditures

For fiscal years (FYs) 2003 to 2016, provincial health care expenditure data were obtained from the Public Accounts of Ontario (**Exhibit A-1** in the Appendix). These documents are prepared under the direction of the Minister of Finance for each fiscal year ending on March 31, as required by the *Financial Administration Act*.[6] The government is responsible for ensuring that transactions are authorized, assets are safeguarded, proper records are maintained and the information included in the statements is presented fairly. The statements are audited by the Auditor General of Ontario to ensure that they are free of significant errors or omissions before public release.[6]

To project health care expenditures for FYs 2017 to 2041, additional years of health care expenditure data dating back to FY 1953 were used to estimate a trend (**Exhibit A-2**). These historic expenditure data were also drawn from the Ontario Public Accounts and were supplemented with data from annual reports of the Ontario Hospital Services Commission for FYs 1953 to 1971.[7]

Certain health care expenditure data were not available for the entire period. For example, the federal *Medical Care Act* did not provide cost sharing for physician services until 1966,[8] and the Ontario Drug Benefit (ODB) Program was not introduced until September 1974.[9] Thus, we did not observe provincial expenditures on physician services and the ODB Program in the Public Accounts until FYs 1966 and 1974, respectively.

In general, the reported health care expenditure categories have been consistent over the last decade. Public Accounts reporting did not change markedly except in response to changes in the structure of the health care system (e.g., the introduction of the Local Health Integration Networks in 2007). However, the Public Account's approach to reporting historical data (from FY 1953 onward) did change frequently as the health care system evolved over this period. These historical expenditures were organized to be as consistent as possible with more recent expenditure data.

Population estimates

Two data sources were used to estimate historic and future population projections.

1. Annual population estimates of single ages were obtained from POHEM. These estimates were used to generate the smoking prevalence models. POHEM is a health microsimulation model that dynamically simulates individuals' disease states, risk factors and health determinants in order to describe and project health outcomes, including disease incidence, prevalence and life expectancy.[5] The population estimates in POHEM were originally derived in DemoSim, which is a related microsimulation model with an emphasis on Canadians demographic measures.[10] Population estimates obtained from POHEM account for births, deaths, immigration and emigration, and are validated against observed Canadian estimates.
2. Aggregated population estimates (of age groups rather than single ages) were obtained from the Ontario Ministry of Finance. These estimates were used to calculate historic and future health care expenditures and, subsequently, smoking-attributable health care expenditures

Smoking health care expenditure ratios

Health expenditure ratios were obtained from the Supplementary Exhibits[11] that accompany the Ten-Year Impact Study.[3] In **Exhibit A-3**, these ratios are presented by three sectors: hospital care, drugs and community care. As in the Ten-Year Impact Study, community care expenditure ratios were used to estimate smoking-attributable health care expenditures for public health care spending that was not included in any of the three sectors (i.e., "other" health care expenditure = total health care expenditure less expenditures on hospital care, drugs and community care).

Analyses

Smoking prevalence

The CCHS data file for Ontario was used to estimate smoking prevalence. These data provide a wide range of sociodemographic information, as well as information on smoking history, including current smoking status, age of initiation and age of cessation (see **Exhibit A-4.1**). In cases where survey respondents indicated they were a current or former smoker and their age of initiation was missing (no cessation ages were missing), we used a multiple imputation model based on gender, birth year, immigration status and ethnicity to obtain the missing initiation ages (approximately 1% of respondents). Thus, for each respondent, we were able to form a life-course smoking history from birth to survey date. For each birth cohort, death and immigration to Canada (into the birth cohort) were captured, with people added to the birth cohort at the time they arrived. Emigration for birth cohorts was not captured. Only people present in Canada at the time of the survey were included.

For each sex, an age-period-cohort (APC) model was constructed to estimate the probability of smoking initiation among those who had not already initiated, for each unique age-cohort combination. These probabilities were adjusted for mortality to account for the increased mortality risk for smokers (see the section on **Mortality Adjustment** for further details). The adjusted initiation rates allowed us to calculate, for each age cohort, a cumulative proportion of ever smokers. Similarly, an APC model was constructed to estimate the probability of smoking cessation among those who were current smokers. The cessation rates allowed us to calculate, for each age cohort, a cumulative probability of ever smokers who had not yet quit. The combination of these two calculations provided the prevalence of current smokers and former smokers in each year for each birth cohort. The APC model assumes that a person smoked in each year from the age at which they started until either the age at which they quit (i.e., a former smoker) or the year of the survey (i.e., a current smoker). Due to a lack of relevant information, we ignored any periods during which a person might have temporarily quit.

Smoking prevalence was modelled based on trends in smoking initiation and cessation. The model is a product of the number of people who initiate smoking and how long they smoke.[12] This relationship is described in **Equation 1**. The duration of smoking was estimated based on the smoking cessation rates.

Equation 1

$$P_c(a,c) = P_e(a,c) \times Q(a,c)$$

Where:

$P_c(a,c)$ = prevalence of current smokers at age a for cohort c

$P_e(a,c)$ = prevalence of ever smokers at age a for cohort c (and P_e reflects initiation probabilities)

$Q(a,c)$ = cumulative proportion of smokers in cohort c who had not ceased smoking by age a (and Q reflects cessation probabilities)

To generate annual population prevalence rates for current and former smokers, the age-specific prevalence rates were multiplied by the POHEM historic and future age-specific population projections. The sum of the age-specific prevalence estimates divided by the sum of the age-specific population estimates was the estimated annual population prevalence. For prevalence estimates, the projected population reflects an open population, which is one that includes births, deaths, immigration and emigration. The modelled annual population prevalence of current and former smokers was compared to historical survey results, using the Canadian Survey of Smoking Habits (1971 to 1986), the Canadian Health Survey (1978), the General Social Survey (1985 and 1991), the Ontario Health Survey (1990), the National Population Health Survey (1994 to 1998) and the Canadian Community Health Survey (2001 to 2013).

Mortality adjustment

Mortality adjustment was performed to adjust smoking incidence for the likelihood that non-smokers live longer than smokers. A weight was calculated for each smoking group (i.e., never smoker or ever smoker, where ever smoker equals current or former smoker) in each historical year, to reflect that a proportion of the population who were ever smokers would have died prior to the survey date.

- In Step 1, a variation of the Mortality Population Risk Tool (MPoRT) (including age, smoking status, and immigration status) was used to calculate each respondent's one-year probability of death.[12] Mortality adjustment was performed for all survey respondents in years in which they were age 30 or older (differential mortality was not applied before age 30, under the assumption that smoking status does not have a differential effect on survival) and the respondents had already immigrated to Canada. The MPoRT model assumes that the proportional hazard of death for smokers is higher than that for non-smokers, and that the hazard varies over time depending on the level and intensity of smoking (i.e., heavy smoker, light smoker, former heavy smoker, former light smoker) and time since quitting.
- In Step 2, we calculated for each year the weighted age-sex mean probabilities of death and compared these to the published yearly age-sex probabilities of death to form a scaling factor for each year/age/sex group.[13]
- In Step 3, we multiplied each respondent's one-year probability of death (from MPoRT) by the appropriate year/age/sex group scaling factor to obtain a scaled probability. For years in which respondents were younger than age 30, we used the published mortality year/age/sex probability as the scaled probability.
- In Step 4, we used each respondent's scaled probability to calculate the probability of survival from any year to the survey response date as the product of all one-year survival probabilities from that year to the survey year. The final yearly weight was calculated as the mean of the cumulative survival probabilities in each sex/smoking-status group. These weights were used in the denominator of Equation 2 to estimate historical smoking incidence.

Equation 2

$$P_{tt} = \frac{P_{tT} / S^S_{tT}}{P_{tT} / S^S_{tT} + (1 - P_{tT}) / S^N_{tT}}$$

P_{tt} = adjusted incidence proportion

P_{tT} = crude incidence proportion

S^S_{tT} = survival probability of smokers at time T to survey

S^N_{tT} = survival probability of non-smokers at time T to survey

Health care expenditures

Historic expenditures

Since health expenditures were incurred in different years and reported in current dollars, we adjusted all smoking-attributable expenditures from FYs 2003 to 2015 to constant 2016 dollars. This was done using the general Consumer Price Index, as recommended by the 2017 guidelines of the Canadian Agency for Drugs and Technologies in Health (CADTH).[14]

Future projections

A quadratic time trend was fit to each sector's time series of expenditure data using all years for which data were available. More specifically, "Hospital" and "Other" were fit using health expenditure data from FYs 1953 to 2016, "ODB" using data from FYs 1974 to 2016, and "Community" using data from FYs 1966 to 2016. These trends were then used to predict expenditures for each health care sector from FYs 2017 to 2041. To convert future projected expenditures to present 2016 dollars, we discounted all projected smoking-attributable expenditures using a discount rate of 1.5%, as recommended in the 2017 CADTH guidelines.[14]

Smoking-attributable health care expenditures by sociodemographic position

Sociodemographic position was determined using the highest lifetime level of educational attainment, selected because it is time-invariant, and with data available only at the survey date, other measures that may change over time could not be used. To allow for completion of education, only those individuals who were age 25 or older at survey completion were included in the models.

Modelling was done using two different methods. All models followed the general methodology of Holford.[15] It was assumed that the eventual highest level of education was not a determinant in initiation of smoking, so the effect was applied only to the cessation portion of the models. In the first method, education level was included as a covariate in the APC cessation model. This would result in constant proportional difference in cessation between education levels over time, with shared APC effects. In the second method, initiation was modelled the same for all education levels, but a separate cessation model was created for each level; this allowed for a varying APC effect for each of the levels.

Findings

Smoking-attributable health care expenditures were estimated from 2003 to 2013 using the CCHS and projected from 2014 to 2041. The analyses were performed in five steps, described in the methods section. The initial step describes the historic and future smoking patterns which, along with smoking health-expenditure ratios, were then combined with former and future health care expenditures.

Step 1. Smoking prevalence: historic trends and future projections

Smoking prevalence was determined by creating a model of smoking status that described historic trends in smoking behaviours for people who were born in 1920 up to 2000. The smoking status model was then used to estimate smoking prevalence, including both historic trends (1960 to 2013) and future projections (2014 to 2041). The smoking status model included models of both smoking initiation and cessation.

Historic smoking initiation and the likelihood of lifetime smoking

Over the past 80 years, the prevalence of ever smokers (that is, current smoker and former smokers) has changed considerably (see **Exhibit 1** for women and **Exhibit 2** for men; see also **Exhibits A-6** to **A-9** for a breakdown by current and former smoking status). Men who were born before 1950

had high rates of smoking by age 20 years (upwards of 60%). Among more recent birth cohorts, the prevalence of ever smoking among men decreased quickly, with about 30% of men born in 1990 reporting smoking. Among women, smoking initiation increased until the 1980s, with those born in the 1960s having the highest smoking initiation rates. Among women born in 1960, about 40% had smoked by the age of 20; among women born in 1990, that proportion had dropped to 20%.

The age at which people started smoking remained virtually unchanged in the past 80 years (people born between 1920 and 2000) with an average age of initiation of 16 years (**Exhibits A-10** and **A-11**). During this same period, the likelihood of smoking initiation decreased quickly after 16 years of age, with few people over the age of 30 ever smoking. An exception was women born in the 1920s and 1930s who continued to initiate smoking in their 30s and 40s.

Historic smoking cessation

The age of smoking cessation also shows a distinct pattern, with cessation rates generally increasing as people age—the pattern is more pronounced for women (**Exhibits A-12** and **A-13**). Over the past 80 years, the increasing rate of smoking cessation contributes to the steady increase in the prevalence of former smokers over time. This also means that smokers in more recent birth cohorts quit smoking at earlier ages and smoke for fewer years than smokers from previous birth cohorts. Historically, few people ceased smoking at young ages, instead quitting in their 40s and older. In more recent years, it has become more common for smokers to quit at younger ages.

Historic and future smoking prevalence

Modelled smoking prevalence has dropped steadily since the 1970s (**Exhibits 3** and **4**). The decrease in smoking prevalence was a result of fewer people taking up smoking and more people quitting (**Exhibits A-10** to **A-15**).

Smoking prevalence among current smokers is projected to drop below 10% ("single-digit prevalence") by 2023 for women and by 2040 for men (**Exhibit 3**). The projected decline in smoking prevalence is a result of recent cohorts being less likely to initiate smoking and, among ever smokers, stopping smoking earlier than historic cohorts. Smoking prevalence is projected to continue to decline, even if there are no future improvements in smoking initiation and cessation. This inevitable decrease in smoking prevalence is a consequence of older people with their high smoking prevalence being slowly replaced by their children and grandchildren who smoke at much lower rates.

The robustness of the decline was further confirmed using sensitivity analyses that varied certain assumptions of the model (i.e., varying the range of years to include as fixed effects in the initiation and cessation models, incorporating mortality adjustment for cessation in addition to initiation, including a rule that subjects who report quitting smoking must have done so at least two years before the survey date, and restricting analyses for those who smoked less than one year). In all these analyses, there was a similar decline in smoking prevalence (with prevalence in 2041 ranging from 3.5% to 12.2% for men and from 0.9% to 5.5% for women).

The prevalence of former smoking increased steadily since the 1970s but plateaued in recent years (**Exhibit 4**). The increase in former smoking prevalence is a consequence of historically high smoking rates. For example, many older Ontarians are former smokers, having smoked earlier in their lives. As these older adults die and are replaced by adults in birth cohorts that have lower levels of smoking initiation, the former-smoking rate will plateau. Due to the limitations of the analytic approach and CCHS data, it was difficult to identify the year in which former-smoker prevalence plateaued and started to decline. In sensitivity analyses, the year in which former-smoker prevalence began to decline varied: from 2022 to 2035 for men and from 2025 to 2029 for women. However, the maximum prevalence of former smokers was consistent: 27% to 28% for men and 22% to 24% for women.

Step 2. Percent contribution of smoking-attributable expenditures for the three sectors

As a fraction or percentage of health care expenditures, smoking-attributable expenditures were projected to decrease by 38%, from 9.5% in 2003 to 5.9% in 2041 (an absolute decrease of 3.6%; **Exhibit 5**).

The hospital sector had the highest smoking-attributable fraction, a reflection of a higher cost ratio for hospital care compared to drugs or community care (**Exhibit A-3).** For hospital care, the smoking-attributable fraction of health care expenditures among Ontarians aged 20 years and older was projected to decline from 15.2% in 2003 to 9.7% in 2041 (**Exhibit 5**), an absolute change of 5.5% or a relative change of 36.0%.

Step 3. Historic and future health care expenditures

Annual health care expenditures for Ontarians aged 20 years and older are projected to increase steadily from $49 billion in 2016 to $79 billion in 2041 (constant 2016 dollars) (**Exhibit A-1**). Projections of health care expenditures for hospital care, drugs and community care suggest that community care expenditures will exceed hospital care expenditures by 2028 (**Exhibit 6**).

Step 4. Dollar amount and overall percentage of smoking-attributable health care expenditures

Total smoking-attributable health care expenditures were projected to increase from $3.2 billion in 2003 to $4.7 billion in 2041 (in constant 2016 dollars; **Exhibit 7**). This increase is largely a reflection of the increased cost of health care over time, meaning the proportion of smoking-attributable expenditures will decrease as the dollar amount of all services increases. The total smoking-attributable health care expenditure for the period from 2003 to 2041 is projected to be $164 billion (in constant 2016 dollars).

Smoking-attributable expenditures for each of the three health care sectors—hospital, drugs and community care—were largely unchanged in 2041 from their 2016 estimates (**Exhibit 7**). Smoking-attributable hospital costs contributed the largest proportion of smoking-attributable expenditures, a consequence of this sector's high smoking-attributable fraction (**Exhibit 5**) as well as representing a high proportion of total health care expenditure (**Exhibit A-1**).

Historically, current smokers had a higher contribution to smoking-attributable health care expenditures compared to former smokers due to their higher hospital cost ratios (**Exhibits 8** and **A-3**). However, the relative contribution of former smokers has increased over time and is projected to continue to do so; this is a consequence of a higher proportion of former smokers compared to current smokers. Current smokers and former smokers both contribute to future health care expenditures but with contrasting attributions. In 2003, the smoking-attributable health care expenditures of current smokers were 55% of the total smoking-attributable fraction, with former smokers contributing the remaining 45% (**Exhibit 8**). In 2041, the attribution fraction related to current smoking is projected to decrease to 29%. The change in contribution of current versus former smokers is related to the more rapid decrease in current smoking prevalence (compared to former smoking prevalence).

The total reduction in smoking-attributable health expenditures from 2003 to 2041 was $51 billion. This number was calculated as the difference in expenditures if the proportion of health care expenditure that can be attributed to smoking had remained at 9.5% (the level in 2003) rather than decreasing as projected over time (to 5.9% in 2041).

Disparities in smoking and health-related costs

Differences in smoking prevalence across sociodemographic positions were large and persisted across the study's timeframe. Smoking prevalence among women with less than a high school education in 2041 was projected to be 17.6%, over three times higher than among women with a university education (4.9%; **Exhibit 9**). Smoking among men with less than a high school education declined more rapidly than among men with a university education (**Exhibit 10**). By 2041, men and women with a high school education were projected to smoke the same proportion as university graduates.

Projecting smoking prevalence by sociodemographic position was challenging. In sensitivity testing, changes to the calculation approach changed the projected rates, especially for female former smokers (**Exhibits A-16** and **A-17**). In addition, there were few choices for which sociodemographic measures could be analyzed by birth cohort. For example, we did not use individual or family income because income recorded when a person was 70 years old may not reflect their income position when they started smoking at age 16. Furthermore, we were not able to validate modelled estimates because there are limited sources of historic smoking prevalence by sociodemographic position.

We did not project smoking-attributable health care expenditures by sociodemographic position due to the above concerns and to the lack of population projections for sociodemographic position. That stated, there will undoubtedly be large differences in smoking-attributable health care expenditures by sociodemographic position, given the differences in past, current and future smoking projections.

Discussion

Between 2003 and 2041, there will be an estimated $51-billion reduction in smoking-attributable health care expenditures in Ontario. This suggests that smoke-free initiatives, such as the Smoke-Free Ontario strategy (with its $45-million expenditure in FY 2017), provide a tremendous return in cost-effectiveness and cost savings. That stated, we did not perform a cost-effectiveness evaluation of Smoke-Free Ontario or other strategies.

There are, however, areas of concern. Despite the reductions, smoking-attributable health care expenditures are very large, both when expressed in dollar terms ($164 billion over the 38 years of this study) and as a percentage of total health care costs (9.5% in 2003 and 5.9% in 2041). Furthermore, the decrease in smoking-attributable health care expenditures is projected to slow because the prevalence of current smokers will continue to steadily decline while the same is not true for former smokers. Given that people will be former smokers from the time they quit (at increasingly younger ages) until they die (at older ages), the prevalence of former smokers will take considerably more time to decline. The health care effects of smoking last for decades, which in turn means that smoking-attributable health care expenditures related to former smokers will persist for many more decades. In 2003, former smokers accounted for 45% of smoking-attributable health care expenditure; by 2041, this is projected to increase to 71%.

Strategies to improve health behaviours, such as smoking prevention, smoke-free policies and other "upstream" practices, can be highly effective not only by improving population health but also by supporting a sustainable health care system—as evidenced in the long-term perspective of this report. There are a number of smoking prevention strategies, such as raising the price of tobacco or reducing young people's access to cigarettes, that are best described as one-time interventions. Considerable effort and public consultation may be required to ensure that these strategies are well-implemented. However, once implemented, the effects of such strategies will accumulate over decades with little further investment. Each new generation of potential smokers benefits from a lower likelihood of smoking initiation. This contrasts with other "downstream" preventive measures, such as medications for diabetes or high blood pressure that must be taken continually for decades to maintain their effect.[16]

How does Ontario's smoking strategy compare to other health strategies?

Smoke-Free Ontario forms part of Ontario's health strategy, *Patients First: Action Plan for Health Care*.[4] We are not aware of calculations of the potential cost effectiveness, cost reduction or sustainability of many of Ontario's other initiatives within the *Patients First* strategy. That stated, there was a clear consensus during follow-up discussions of our preceding report[3] that Ontario's smoking strategy was considerably more effective in ensuring sustainable health care compared to other strategies in Ontario's *2012 Action Plan for Health Care*.[17] Those discussions highlighted the importance of preventive interventions, not only for smoking but also for other health behaviours, as well as strategies to improve sociodemographic conditions. Ontario's Basic Income Pilot Project is an example of a strategy that seeks, amongst other outcomes, to support a sustainable health care system through improving health.[18]

How does this study compare to other studies?

In Canada, smoking prevalence is most commonly assessed using the CCHS—the data source used in this study—and CTADS/CTUMS. CTADS/CTUMS generally produce lower smoking prevalence rates than the CCHS.[17] Potential implications of the differences in smoking ascertainment are discussed in the **Limitations and Interpretive Cautions** section of this report.

Smoking-attributable expenditures have been estimated for Manitoba[19] and, more recently for Canada, in a report conducted by the Conference Board of Canada.[2] A strength of the Conference Board report was its national perspective and its inclusion of indirect costs, such as lost productivity due to disability. However, the Conference Board report assumed that the health care expenditure cost ratio for smokers versus non-smokers was the same as a mortality ratio reported in a U.S. study.[20] We used specific health care sector cost ratios that were lower than those used in the Conference Board report, especially for the categories of drugs and community care. Additionally, the Conference Board report had a narrower scope than our study; it examined smoking attribution for 28 conditions (compared to all-cause smoking attribution) and was limited to hospital, drug and physician services (compared to most government-funded health services, including home care and long-term care). A strength of our study is that we included all causes of health care use, not just for specific conditions, given that smoking is associated with increased disease risk for many diseases.[20,21] As well, smoking is associated with increased health care use due to higher rate of complications, longer recovery periods and other factors.[22] The narrower scope of the Conference Board report resulted in estimates of smoking-attributable health care expenditures that were considerably lower than the estimates in this study ($2.3 billion versus $4.0 billion in 2012).

Statistics Canada's Population Health Model (POHEM) projects smoking prevalence along with other health behaviours, conditions and measures (e.g., physical activity, diabetes, body mass index). The POHEM and related OncoSim models (which are cancer-specific) generated smoking projections that are similar to those in this study. However, our projections of future smoking prevalence rates (from about 2030 onward) are lower than those produced by the POHEM and OncoSim models. Our study has generated unique birth cohorts of smokers that can be used to examine generational changes in smoking initiation and cessation. The smoking prevalence projections we were able to derive from these generational changes likely account for the somewhat lower estimates than those generated by POHEM and OncoSim. POHEM and OncoSim have many strengths, including the ability to dynamically model additional predictors for health and health care and make projections for several sociodemographic factors; however, they do not yet incorporate sociodemographic factors into smoking projections. Consideration could be given to incorporating our smoking projection models into POHEM and OncoSim.

Limitations and Interpretive Cautions

In general, the study assumptions will result in lower life-course smoking rates and historic smoking prevalence rates, compared to an unbiased estimate. For example, nonsurviving smokers likely have lower quit rates than are estimated in the present study; this will result in lower historic prevalence estimates of ever smokers. Also, because occasional smokers are underascertained in the retrospective data, they will be underrepresented in the current estimates.[23]

A further limitation of this study is the difficulty in obtaining point estimates of smoking prevalence. Unlike other countries, Canada does not collect smoking status in the national census, so researchers must rely on national surveys to obtain these estimates.[24] Statistics Canada administers two main surveys that collect data on smoking: the Canadian Community Health Survey (CCHS; used in this study) and the Canadian Tobacco, Alcohol and Drugs Survey (CTADS). Prior to 2013, information gathered by the CTADS was collected in two separate surveys: the Canadian Tobacco Use Monitoring Survey (CTUMS) and the Canadian Alcohol and Drugs Use Monitoring Survey (CADUMS). Gagné compared estimates of current smoking status (daily and non-daily smokers) from the two surveys for 2001 to 2013 and found that the CCHS produced consistently higher estimates of smoking prevalence across all years under study.[24]

In this study, we chose to use the CCHS because, unlike the CTADS/CTUMS, it contains a wide array of additional data on health behaviours that are correlated with smoking status (e.g., physical activity) and are associated with the outcome (i.e., health care costs). By not controlling for these factors, we may overattribute their expenditures to smoking, as opposed to other risk factors. The effect may lead to an overestimate of smoking-attributable expenditures. The questions in the CTADS and CTUMS surveys, on the other hand, are more focused on smoking than on health behaviours.

See **Exhibit A-5** for the expanded list of assumptions and interpretive cautions.

Conclusions

This study confirms that smoking is a major contributor to health care expenditures. Previous studies have also described the role of smoking as a major burden of poor health. The good news is that smoking-attributable health care expenditures are projected to decrease through to 2041. This report's long timeframe (2003 to 2041) highlights the accumulated benefits of health preventive strategies, such as Smoke-Free Ontario. However, the health effects of smoking will persist long after people quit, resulting in smoking-attributable health expenditures for many decades. Our study's long-term perspective supports the view that preventing the onset of unhealthy behaviours is a key strategy for both promoting health and maintaining a sustainable health care system.

Other health objectives identified in *Patients First* have not been similarly evaluated for their effect on future health care expenditures, even though "making evidence-based decisions on value and quality, to sustain the system for generations to come" is an objective of *Patients First*.[4] It seems ironic that programs implemented outside the health care system, such as the Basic Income Pilot Project, are being evaluated for their health care impact, while strategies that are within the scope of the Ministry of Health and Long-term Care are not. We anticipate that evaluations of most other health strategies, in particular "down stream" health care strategies, will not demonstrate as large a role for a sustainable health care system as smoking prevention and other strategies to improve health behaviours and strengthen sociodemographic conditions.

Exhibits

EXHIBIT 1 Historic and projected prevalence of ever smokers among women aged 20 and older, by birth cohort, in Ontario, 1928 to 2041

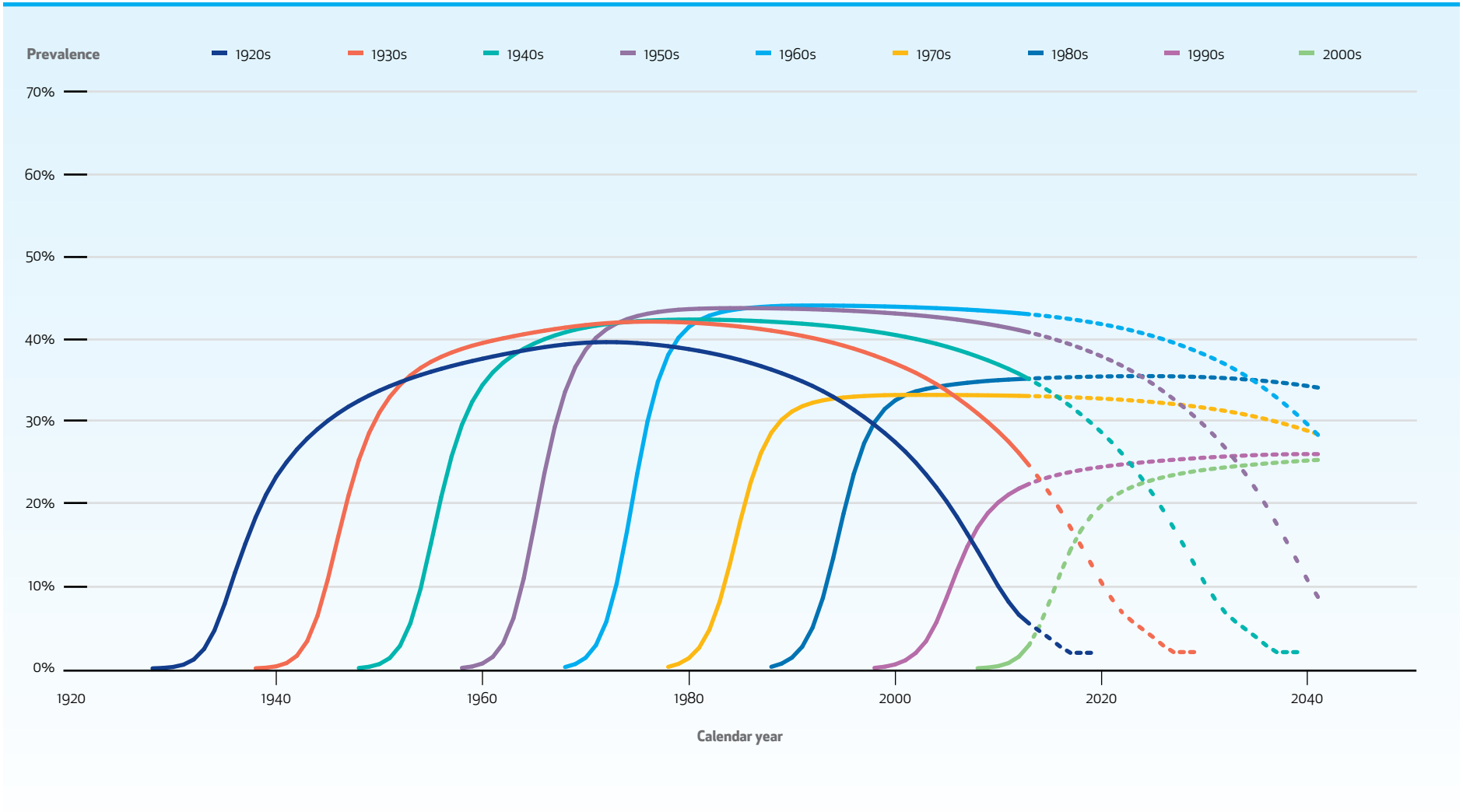


EXHIBIT 2 Historic and projected prevalence of ever smokers among men aged 20 and older, by birth cohort, in Ontario, 1928 to 2041

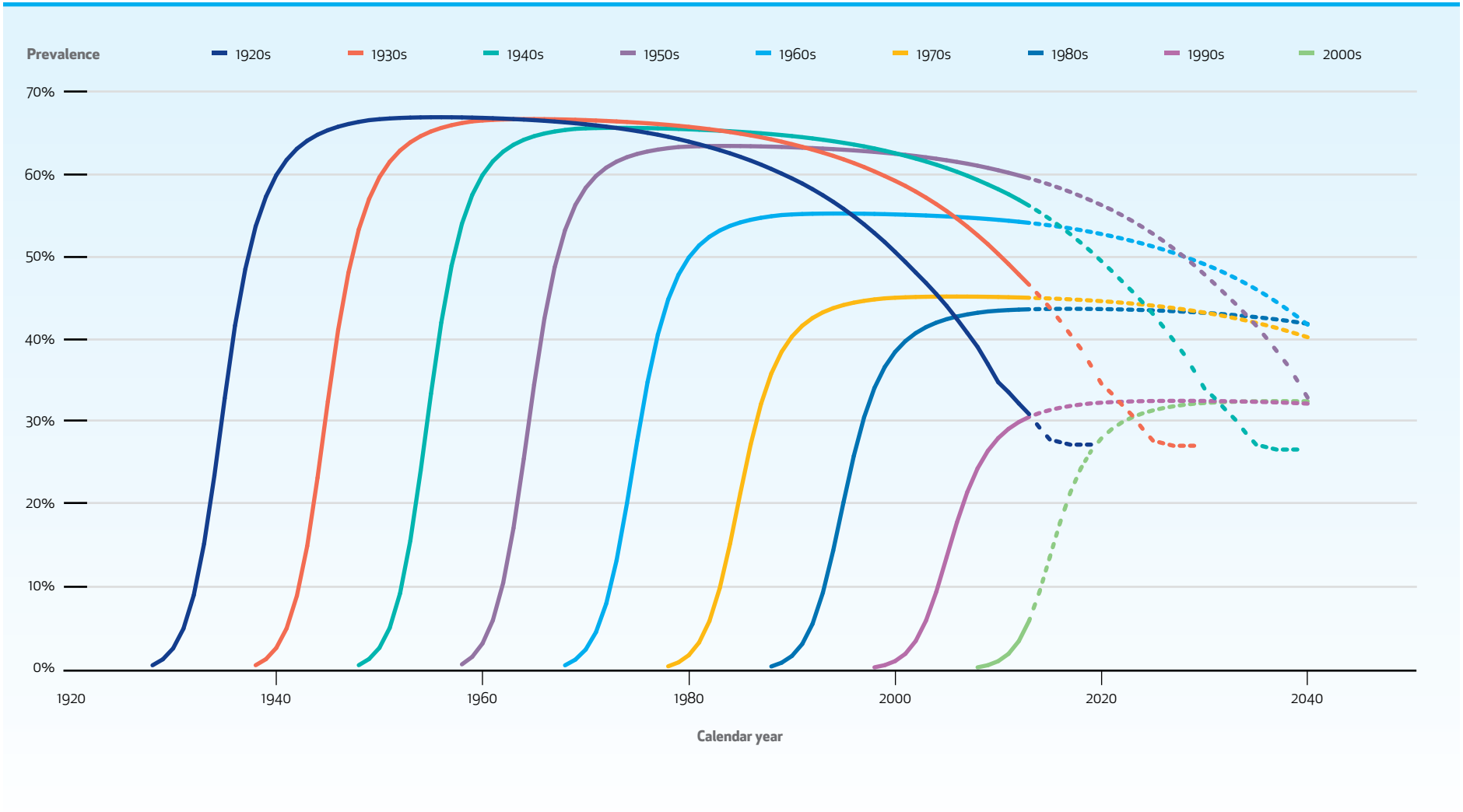
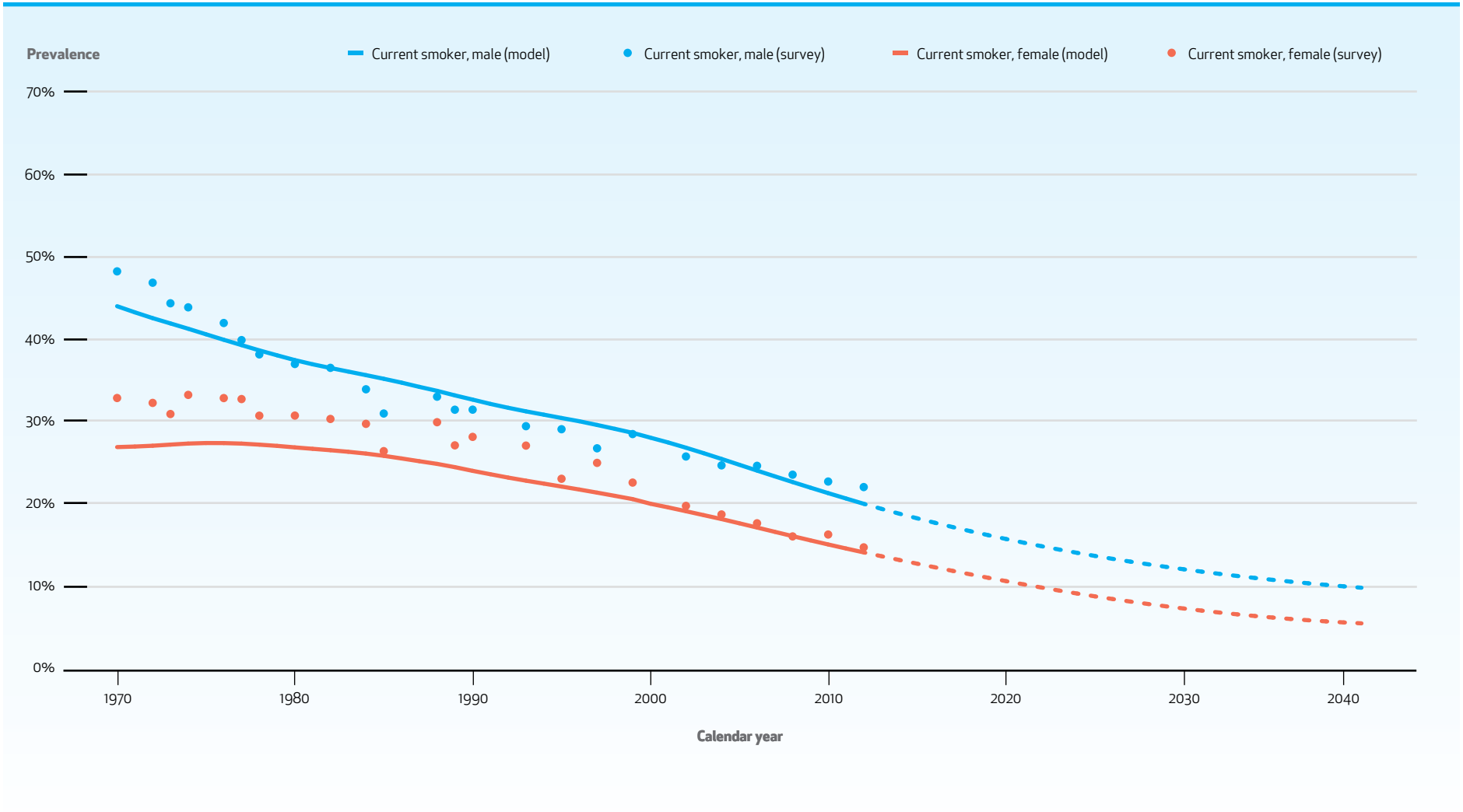
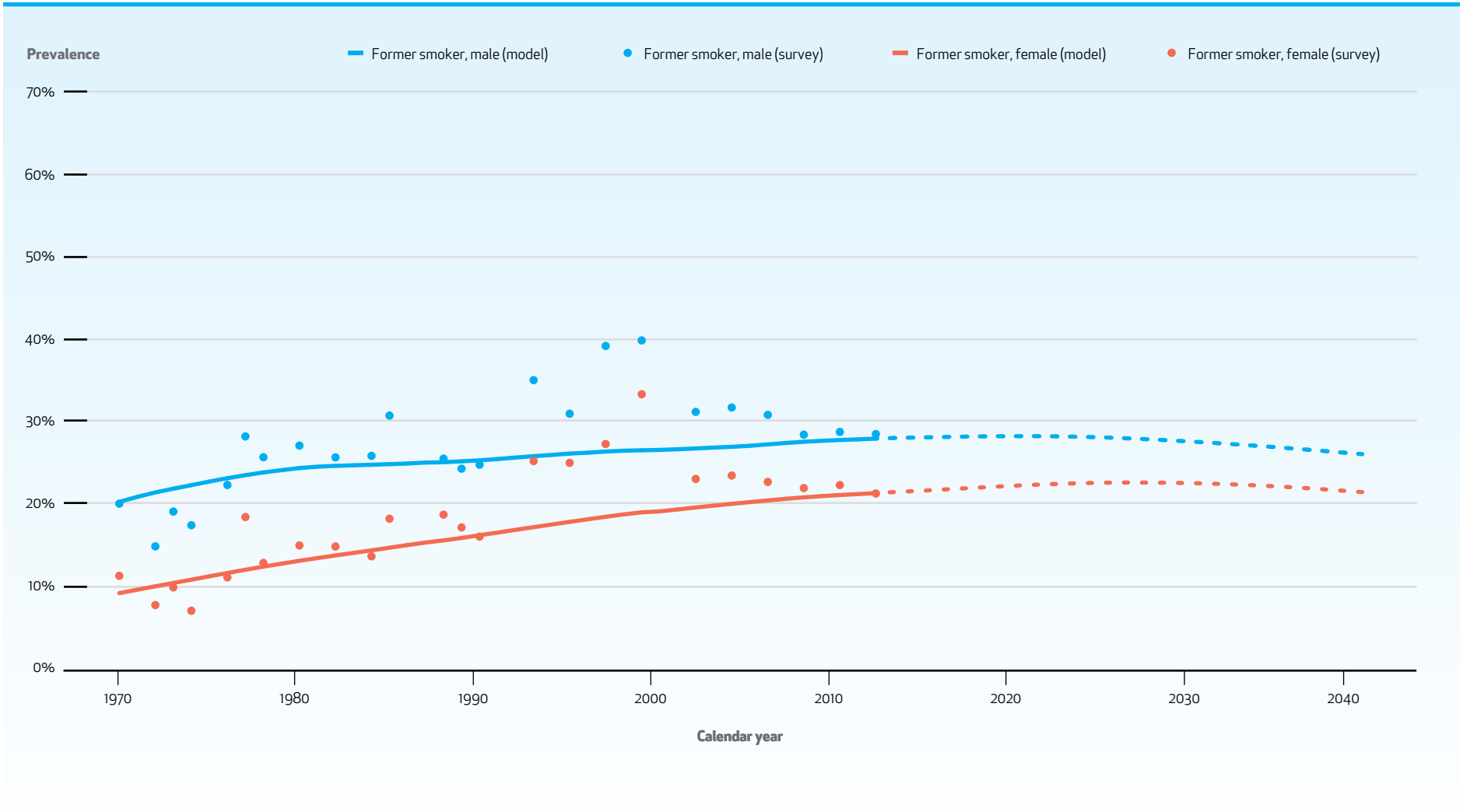


EXHIBIT 3 Historic and projected prevalence of current smokers among men and women aged 20 and older, by modelled estimates and unadjusted survey results, in Ontario, 1971 to 2041*



*Modelled estimates from the age-period-cohort model.

EXHIBIT 4 Historic and projected prevalence of former smokers among men and women aged 20 and older, by modelled estimates and unadjusted survey results, in Ontario, 1971 to 2041*



*Modelled estimates from the age-period-cohort model are weighted by population.

EXHIBIT 5 Historic and projected smoking-attributable fraction for individuals aged 20 and older, by total expenditure and health care sector, in Ontario, 2003 to 2041

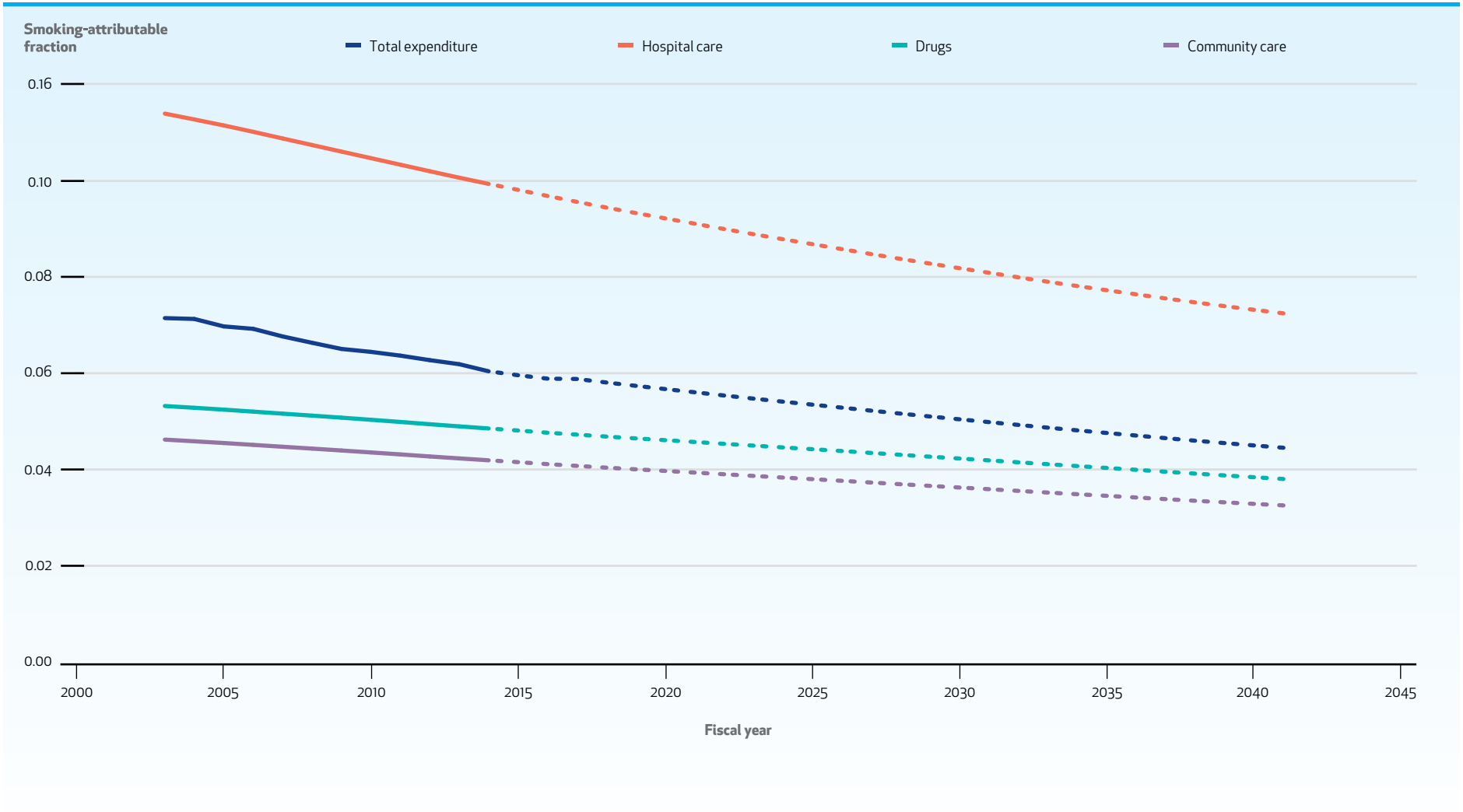
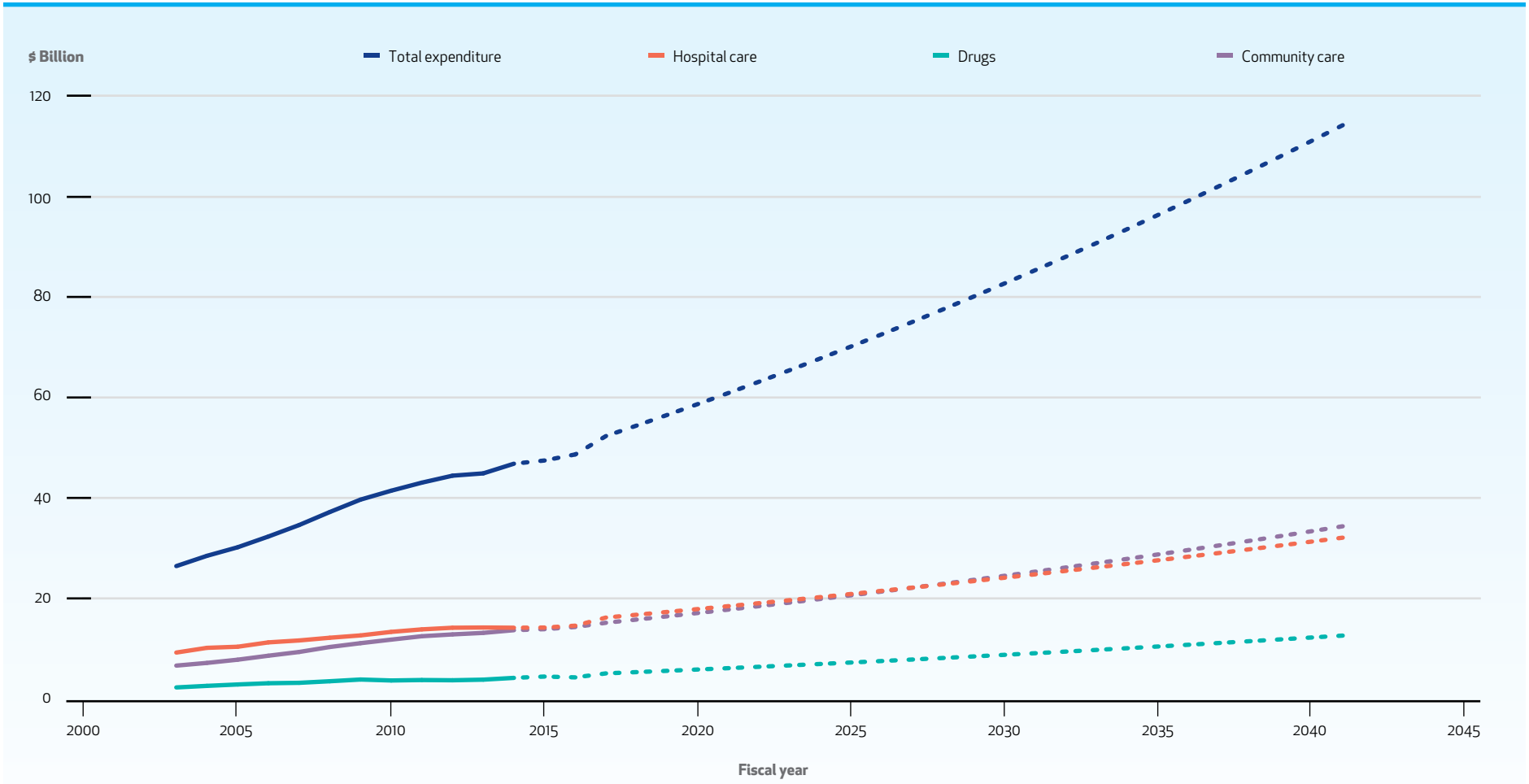
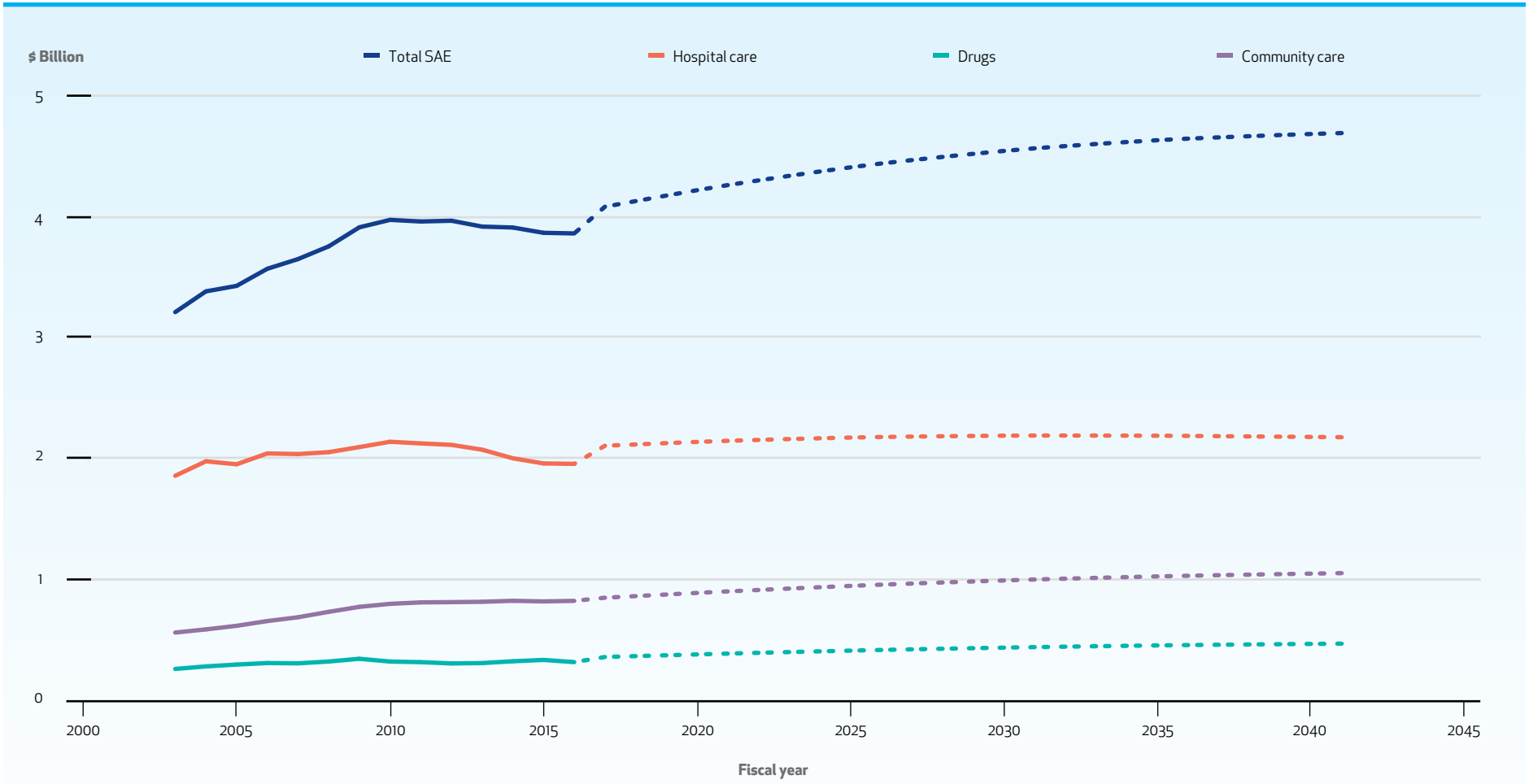


EXHIBIT 6 Historic and projected health care expenditure for individuals aged 20 and older, by total expenditure and health care sector, in Ontario, 2003 to 2041*



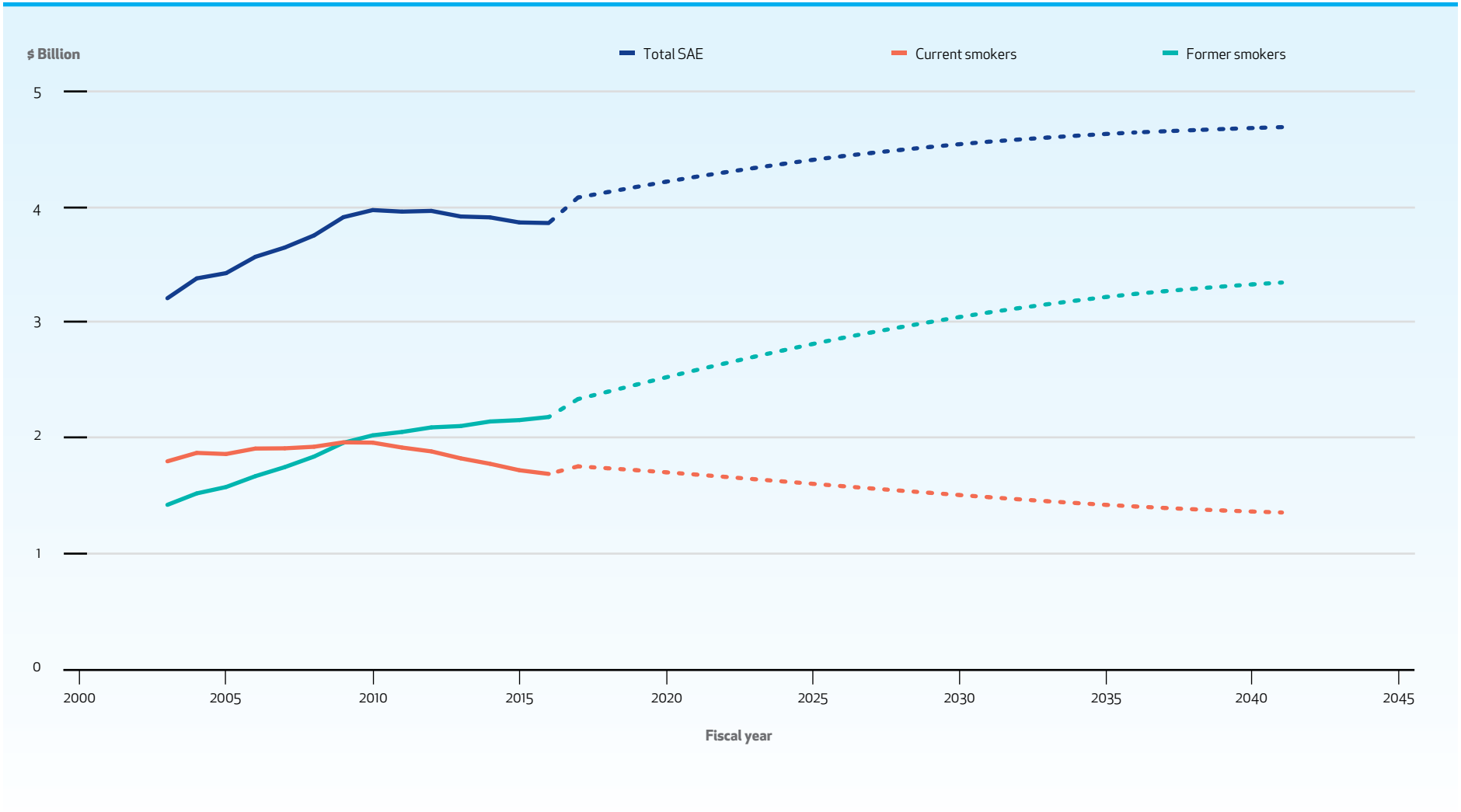
*In current Canadian dollars.

EXHIBIT 7 Historic and projected smoking-attributable health care expenditure (SAE) for individuals aged 20 and older, by total SAE and health care sector, in Ontario, 2003 to 2041*



*In constant 2016 Canadian dollars.

EXHIBIT 8 Historic and projected smoking-attributable health care expenditure (SAE) for individuals aged 20 and older, by total SAE and smoking status, in Ontario, 2003 to 2041*



*In constant 2016 Canadian dollars.

EXHIBIT 9 Historic and projected prevalence of current smokers among women aged 20 and older, by level of education, in Ontario, 1971 to 2041

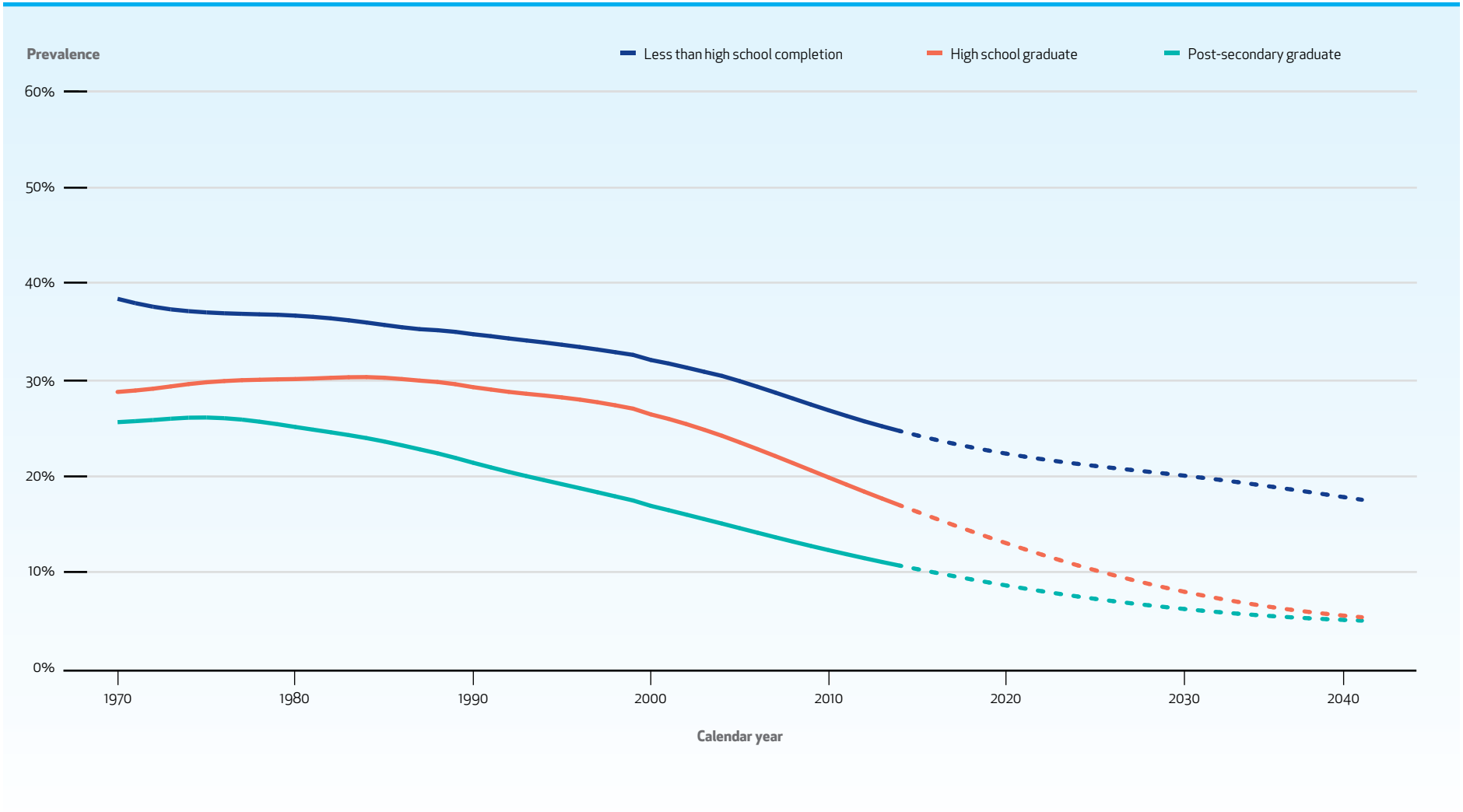
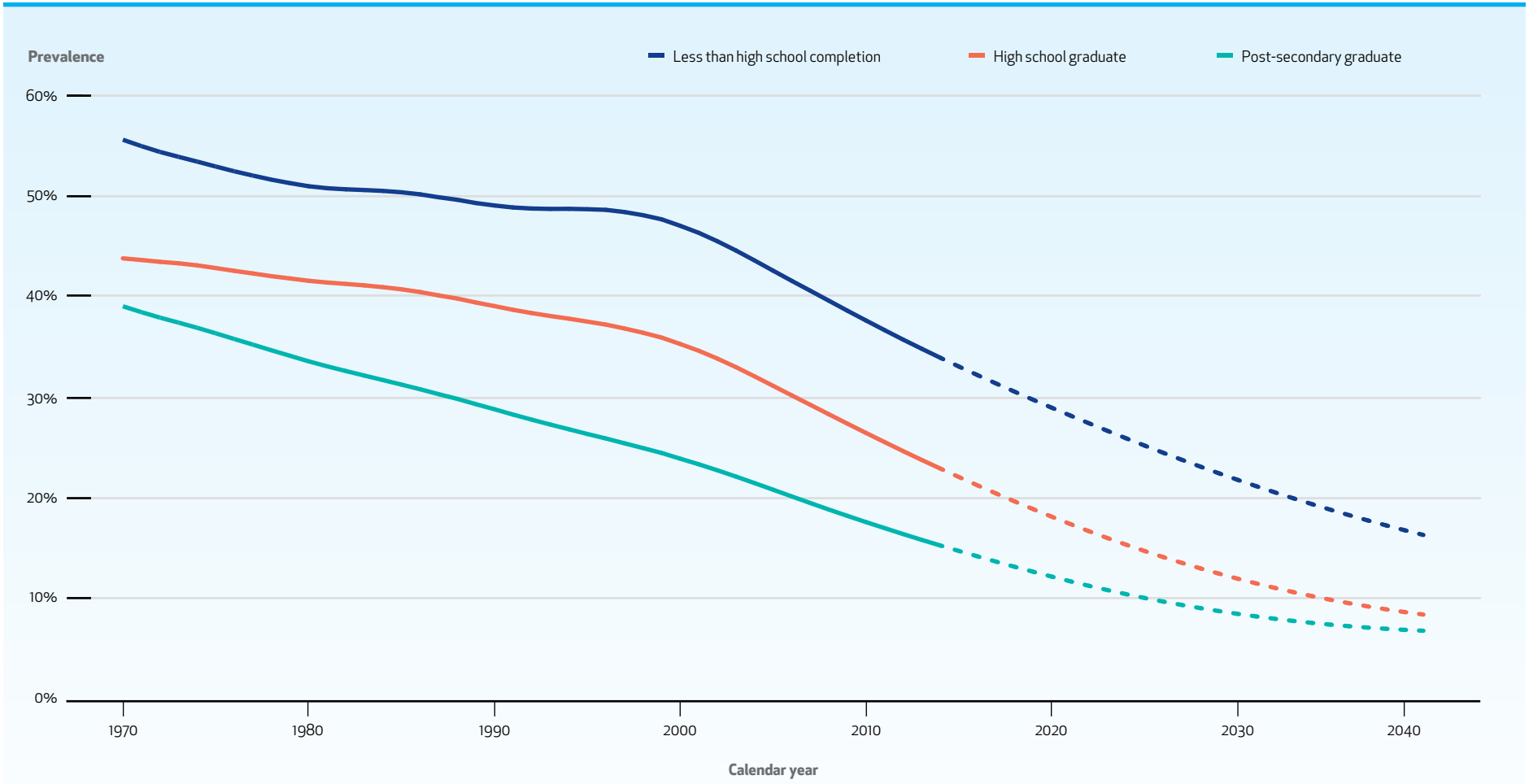


EXHIBIT 10 Historic and projected prevalence of current smokers among men aged 20 and older, by level of education, in Ontario, 1971 to 2041



Appendix

EXHIBIT A-1 Adjusted annual provincial health expenditures for individuals aged 20 and older, by health care sector, in Ontario, 2003 to 2041*

Fiscal Year	Hospital Care, $	Drugs, $	Community Care, $	Other, $	Total, $	Consumer Price Index*	Discount Rate
2003	12,187,661,029	3,522,409,494	8,946,283,197	9,015,265,214	33,671,618,934	102.8	
2004	13,119,600,435	3,842,772,769	9,443,153,123	9,162,775,784	35,568,302,111	104.7	
2005	13,098,845,813	4,091,783,826	10,007,364,815	9,648,798,623	36,846,793,076	107.0	
2006	13,869,583,534	4,303,020,022	10,746,008,985	9,732,477,812	38,651,090,352	109.1	
2007	14,009,944,338	4,305,186,716	11,367,800,106	10,761,612,562	40,444,543,723	111.5	
2008	14,296,738,668	4,559,538,525	12,226,083,214	11,356,820,330	42,439,180,737	114.1	
2009	14,780,133,032	4,932,512,198	13,043,734,195	12,340,125,992	45,096,505,417	114.4	
2010	15,287,363,910	4,633,946,371	13,589,450,538	12,729,784,415	46,240,545,234	116.5	
2011	15,389,207,435	4,599,201,926	13,930,518,654	12,730,139,206	46,649,067,221	119.9	
2012	15,505,481,608	4,481,711,207	14,105,152,892	13,329,323,425	47,421,669,133	121.7	
2013	15,413,171,518	4,567,972,462	14,294,008,771	13,198,447,778	47,473,600,529	122.8	
2014	15,074,573,634	4,841,881,939	14,571,196,483	14,050,590,978	48,538,243,035	125.2	
2015	14,939,905,355	5,056,255,489	14,615,025,143	14,041,167,842	48,652,353,828	126.6	
2016	15,106,341,277	4,820,873,408	14,844,761,653	14,404,130,061	49,176,106,399	128.4	
2017	16,478,492,775	5,534,539,286	15,454,764,211	14,586,220,645	52,054,016,917		1.015
2018	16,773,132,646	5,697,508,720	15,843,252,296	14,992,905,803	53,306,799,465		1.015
2019	17,064,318,867	5,859,587,328	16,230,111,180	15,397,526,331	54,551,543,706		1.015
2020	17,351,968,547	6,020,682,119	16,615,164,624	15,799,885,662	55,787,700,952		1.015
2021	17,636,005,339	6,180,703,467	16,998,244,902	16,199,797,363	57,014,751,071		1.015
2022	17,916,359,172	6,339,565,973	17,379,190,814	16,597,077,859	58,232,193,818		1.015
2023	18,192,961,000	6,497,189,681	17,757,849,210	16,991,558,521	59,439,558,413		1.015
2024	18,465,747,826	6,653,497,199	18,134,068,097	17,383,073,183	60,636,386,305		1.015
2025	18,734,660,834	6,808,414,985	18,507,708,246	17,771,463,262	61,822,247,327		1.015
2026	18,999,646,851	6,961,874,525	18,878,631,324	18,156,582,454	62,996,735,153		1.015
2027	19,260,654,966	7,113,809,997	19,246,706,431	18,538,288,117	64,159,459,510		1.015

EXHIBIT A-1 *Continued*

Fiscal Year	Hospital Care, $	Drugs, $	Community Care, $	Other, $	Total, $	Consumer Price Index*	Discount Rate
2028	19,517,634,975	7,264,157,817	19,611,809,845	18,916,441,305	65,310,043,942		1.015
2029	19,770,546,639	7,412,860,312	19,973,818,582	19,290,914,633	66,448,140,166		1.015
2030	20,019,350,096	7,559,861,792	20,332,621,265	19,661,585,564	67,573,418,717		1.015
2031	20,264,005,970	7,705,108,939	20,688,107,016	20,028,339,386	68,685,561,311		1.015
2032	20,504,484,241	7,848,552,335	21,040,171,586	20,391,064,411	69,784,272,573		1.015
2033	20,740,755,067	7,990,146,301	21,388,715,647	20,749,656,462	70,869,273,476		1.015
2034	20,972,788,890	8,129,847,225	21,733,646,118	21,104,015,663	71,940,297,897		1.015
2035	21,200,564,939	8,267,613,531	22,074,871,649	21,454,052,134	72,997,102,253		1.015
2036	21,424,062,435	8,403,407,852	22,412,305,511	21,799,678,425	74,039,454,223		1.015
2037	21,643,260,705	8,537,193,927	22,745,871,052	22,140,809,555	75,067,135,239		1.015
2038	21,858,147,321	8,668,939,489	23,075,487,449	22,477,369,951	76,079,944,210		1.015
2039	22,068,709,687	8,798,613,252	23,401,085,079	22,809,288,915	77,077,696,934		1.015
2040	22,274,936,449	8,926,187,714	23,722,592,893	23,136,496,457	78,060,213,513		1.015
2041	22,476,820,064	9,051,636,238	24,039,947,914	23,458,934,006	79,027,338,223		1.015

*Consumer Price Index adjusted for 2003 to 2015 and discounted for 2017 to 2041.

EXHIBIT A-2 Annual provincial health expenditures, by health care sector, in Ontario, 1953 to 2016

Fiscal Year	Hospital Care, $	Drugs, $	Community Care, $	Other, $	Total, $
1953	9,352,448			43,040,925	52,393,373
1954	9,617,593			47,579,578	57,197,171
1955	11,182,729			48,186,403	59,369,132
1956	12,865,969			49,634,428	62,500,398
1957	13,187,168			52,777,918	65,965,085
1958	47,881,683			63,892,867	111,774,550
1959	163,715,811			67,292,221	231,008,031
1960	192,933,085			73,130,166	266,063,251
1961	219,735,377			82,801,280	302,536,656
1962	248,890,133			89,714,656	338,604,789
1963	278,508,696			98,261,803	376,770,499
1964	311,630,933			111,617,256	423,248,189
1965	352,279,686			128,079,602	480,359,288
1966	405,963,560		28,418,110	172,250,738	606,632,408
1967	485,903,829		60,707,770	225,815,490	772,427,089
1968	580,880,542		94,070,860	273,042,882	947,994,284
1969	671,267,717		216,009,427	237,331,759	1,124,608,902
1970	762,991,663		437,658,797	228,871,474	1,429,521,934
1971	854,441,780		482,025,980	479,908,092	1,816,375,852
1972	955,313,570		547,381,073	530,430,208	2,033,124,851
1973	1,024,980,984		567,352,083	601,940,127	2,194,273,194
1974	1,338,949,468	9,107,393	659,675,746	570,978,523	2,578,711,130
1975	1,554,264,297	44,171,288	755,364,843	676,382,101	3,030,182,529
1976	1,861,016,166	69,813,166	817,662,073	702,853,153	3,451,344,558
1977	1,966,410,155	86,656,580	918,875,496	722,786,597	3,694,728,828

EXHIBIT A-2 *Continued*

Fiscal Year	Hospital Care, $	Drugs, $	Community Care, $	Other, $	Total, $
1978	2,024,455,905	106,635,350	1,049,108,397	803,613,264	3,983,812,916
1979	2,160,988,137	127,134,344	1,156,868,642	847,331,686	4,292,322,809
1980	2,440,629,083	156,468,955	1,381,637,123	940,397,568	4,919,132,729
1981	2,949,530,581	196,900,013	1,610,940,717	1,084,806,726	5,842,178,037
1982	3,428,059,229	250,104,788	1,933,027,989	1,197,499,129	6,808,691,135
1983	3,804,249,921	303,194,005	2,252,628,457	1,272,726,134	7,632,798,517
1984	4,109,124,533	348,313,740	2,521,894,656	1,421,885,841	8,401,218,770
1985	4,454,824,806	413,363,697	2,878,858,349	1,585,740,960	9,332,787,812
1986	4,940,235,797	493,930,714	3,379,989,572	1,747,258,974	10,561,415,057
1987	5,329,318,472	592,481,003	3,875,176,991	1,827,403,799	11,624,380,265
1988	5,816,108,383	683,995,726	4,218,723,599	1,955,945,384	12,674,773,092
1989	6,628,218,254	766,160,425	4,553,570,899	2,304,098,212	14,252,047,790
1990	6,686,942,270	912,754,084	5,065,721,961	2,498,009,209	15,163,427,524
1991	7,580,606,652	1,038,367,443	5,804,841,730	2,607,551,809	17,031,367,634
1992	7,748,912,354	1,193,815,626	5,528,725,221	2,761,911,426	17,233,364,627
1993	7,714,621,615	1,185,341,650	5,483,891,717	3,407,067,625	17,790,922,607
1994	7,682,324,507	1,161,869,538	5,696,107,603	3,457,065,004	17,997,366,652
1995	7,578,674,562	1,323,023,129	5,692,334,462	3,449,361,918	18,043,394,071
1996	7,740,248,045	1,211,572,066	5,847,086,016	3,622,173,369	18,421,079,496
1997	7,096,424,583	1,289,091,525	6,441,831,740	3,848,406,412	18,675,754,260
1998	7,953,100,996	1,566,640,046	6,677,554,650	4,015,405,052	20,212,700,744
1999	8,087,520,985	1,709,451,464	6,925,426,504	4,725,666,640	21,448,065,593
2000	9,409,955,119	1,981,869,620	7,449,426,204	6,208,108,385	25,049,359,328
2001	8,815,967,008	2,249,813,108	7,301,866,427	6,555,345,661	24,922,992,204
2002	9,840,376,119	2,571,510,374	7,567,570,117	7,051,975,180	27,031,431,790

EXHIBIT A-2 *Continued*

Fiscal Year	Hospital Care, $	Drugs, $	Community Care, $	Other, $	Total, $
2003	10,951,428,038	2,865,977,889	8,185,829,218	7,940,174,312	29,943,409,457
2004	11,966,433,941	3,184,426,754	8,760,115,148	8,185,036,068	32,096,011,911
2005	12,182,706,299	3,461,746,046	9,487,452,422	8,798,742,438	33,930,647,205
2006	13,152,706,765	3,711,905,090	10,328,913,994	9,036,640,122	36,230,165,971
2007	13,578,076,269	3,791,621,003	11,154,317,474	10,209,871,434	38,733,886,180
2008	14,179,130,177	4,109,269,222	12,262,365,199	11,017,657,525	41,568,422,123
2009	14,762,995,569	4,466,157,867	13,116,839,939	12,025,914,943	44,371,908,318
2010	15,497,814,925	4,277,188,467	13,885,126,257	12,613,021,501	46,273,151,150
2011	16,056,370,381	4,382,385,331	14,632,538,806	12,988,649,250	48,059,943,768
2012	16,383,940,859	4,343,407,408	15,021,501,514	13,781,730,705	49,530,580,486
2013	16,378,828,854	4,462,457,864	15,308,615,967	13,731,429,704	49,881,332,389
2014	16,370,455,672	4,817,605,278	15,886,536,156	14,912,632,739	51,987,229,845
2015	16,397,662,496	5,089,810,986	16,084,216,065	15,058,698,896	52,630,388,443
2016	16,807,913,300	4,924,431,006	16,540,291,943	15,656,615,847	53,929,252,096

EXHIBIT A-3 Health expenditure ratios for men and women aged 20 and older, by health care sector and smoking status, in Ontario

	Hospital Care		Drugs		Community Care	
Smoking Status	**Men**	**Women**	**Men**	**Women**	**Men**	**Woman**
Current	1.61	1.35	1.17	1.14	1.15	1.12
Former	1.32	1.27	1.15	1.21	1.15	1.15
Non-smoker	Reference	Reference	Reference	Reference	Reference	Reference
Unknown	1.53	0.79	1.13	1.23	1.36	0.97

EXHIBIT A-4.1 Ascertainment of smoking exposure from the Canadian Community Health Survey

Survey questions

- **01a** – Have you smoked more than 100 cigarettes in your lifetime? Yes/No/Don't know
- **01b** – Have you ever smoked a whole cigarette? Yes/No/Don't know
- **01c** – Age at which you smoked first whole cigarette? #/Don't know
- **202** – What is your current smoking status? Daily/Occasional/Non-smoker/Don't know
- **203** – Age at which you started smoking daily (for current daily smokers)? #/Don't know
- **05d** – Have you ever smoked daily (for current occasional/non-smokers)? Yes/No/Don't know
- **06** – When did you stop smoking (for former occasional)?
- **207** – Age at which you started smoking daily (for current occasional/non-smokers)? #/Don't know
- **10** – When did you stop smoking (for former daily)?
- **SMKDSTP** (derived variable, from 06 and 10) – How many years ago did you stop completely? #/Don't know

Exclusions were made if start or stop (where appropriate) age could not be determined, or if there was inconsistency in the answers. Where available, age at first whole cigarette was used as the inception age.

People who indicated that they smoked less than 100 cigarettes in their lifetime (01a = No) were classified as non-smokers. People who indicated 01a = Don't know were excluded, classified as non-smokers if 01b = No, or classified as current smokers if 01b = yes, 01c = valid, and 202 = daily or occasional.

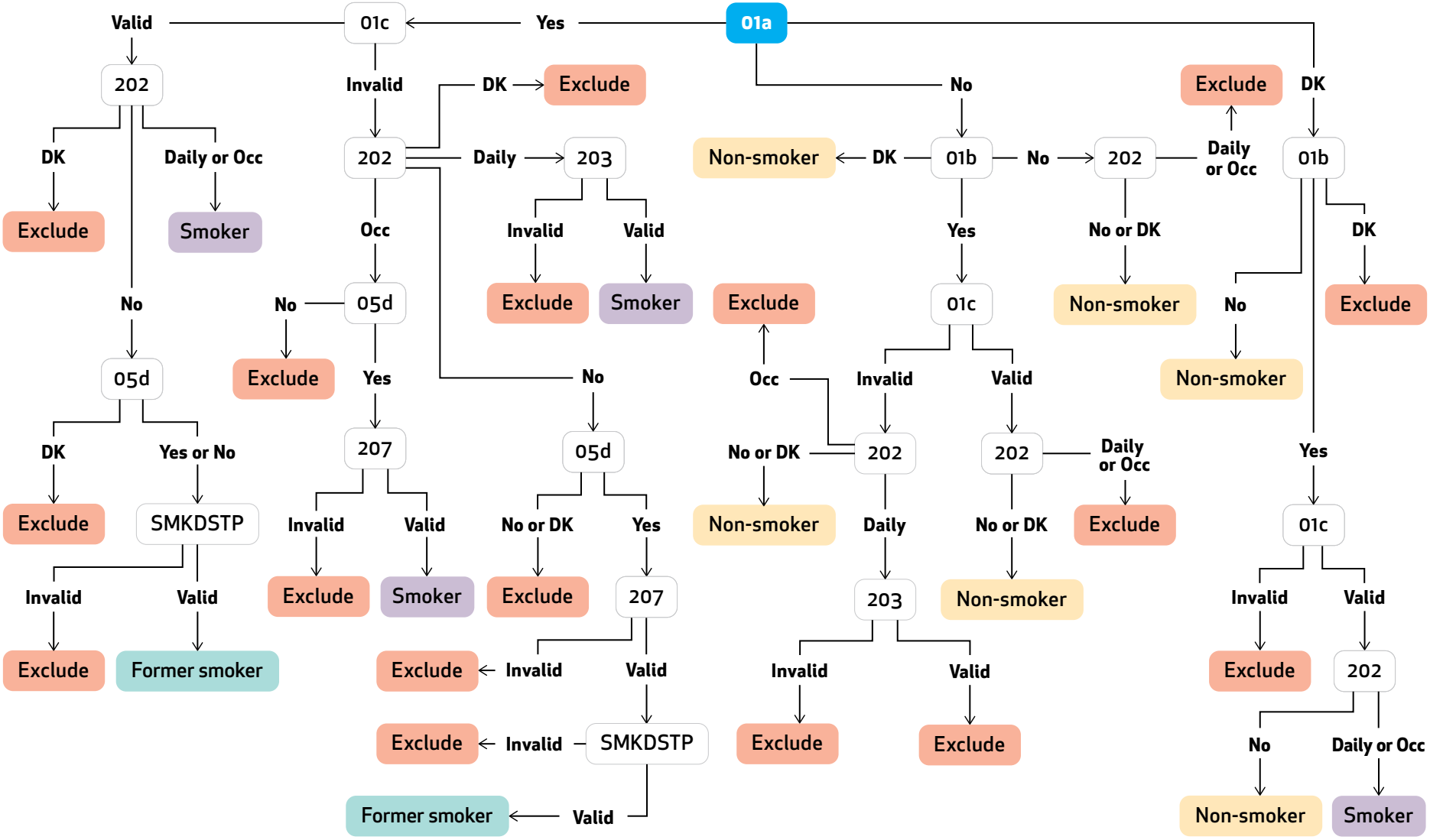
Age definitions, by smoking classification

Non-smokers (01a = No):
- Age at initiation = missing
- Age at cessation = missing

Current smokers (01a = Yes, 202 = Daily/Occasional):
- Age at initiation = 01c
- Age at cessation = missing

Former smokers (01a = Yes, 202 = Non-smoker):
- Age at initiation = 01c
- Age at cessation = Survey age – SMKDSTP

EXHIBIT A-4.2 Flow diagram for ascertainment of smoking exposure from the Canadian Community Health Survey



Abbreviations: DK = Don't know; Occ = Occasional; SMKDSTP = Number of years since stopped smoking completely.

EXHIBIT A-4.3 Lifetime smoking patterns

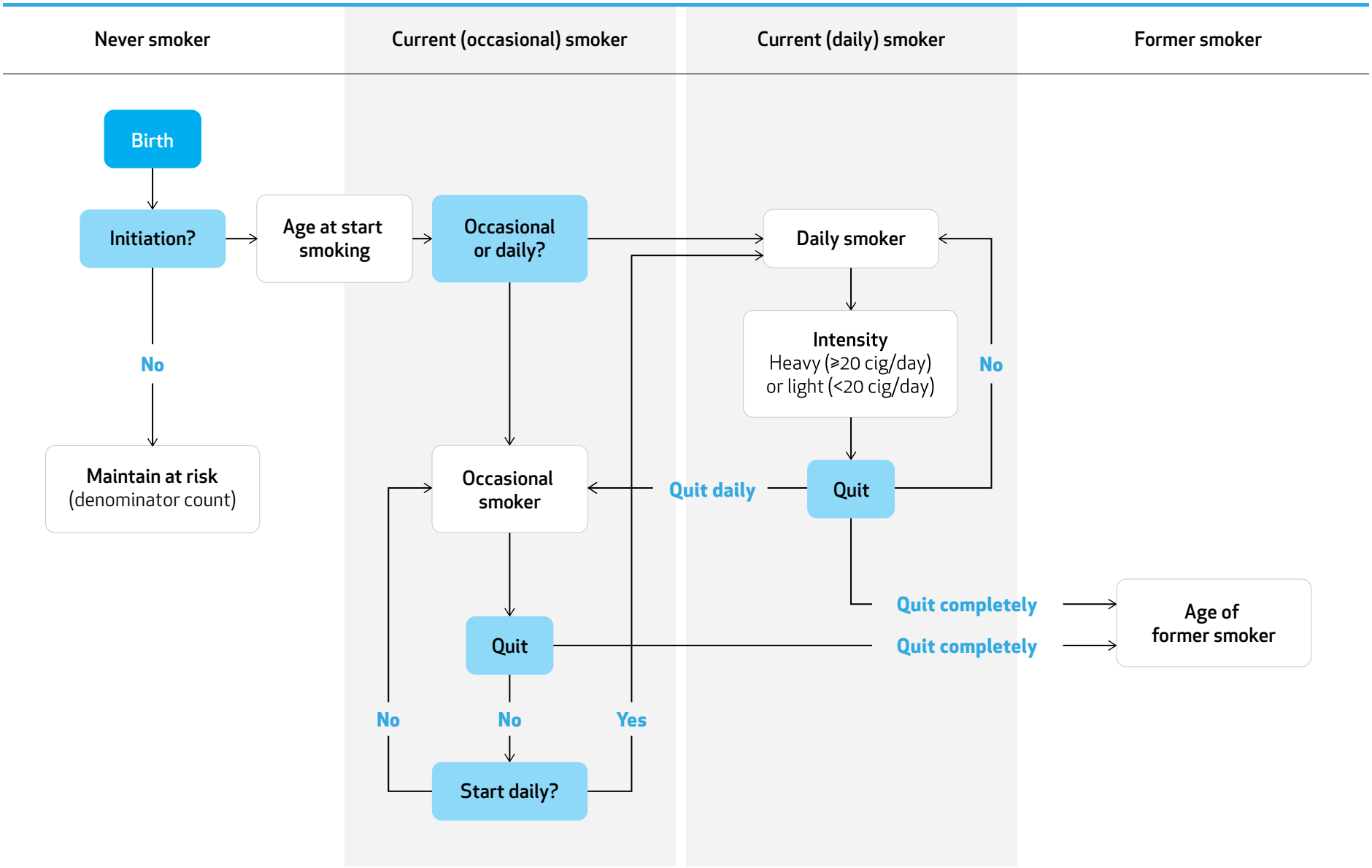


EXHIBIT A-5 Expanded list of report assumptions and interpretive cautions

Assumption/Approach	Description	Effect on Findings	Summary Effect on SAE Projections*
Smoking projections			
The Ontario population	The report's findings reflect Ontarians aged 20 years and older. Smokers and non-smokers younger than age 20 were excluded from the cost estimates but were considered when creating the historic and future smoking projection model (the APC model).	Excluding smokers who are less than 20 years of age will result in an underestimate of the SAE. However, in general, health care expenditures for individuals younger than 20 years are lower than those for older adults. As well, smoking initiation typically begins in the mid-teen years. Consequently, duration of smoking among the young is short (in contrast to those who are older). Furthermore, SAEs are often related to chronic diseases, which are less prevalent among people younger than age 20 years. The effect of shorter smoking duration and fewer chronic diseases can be seen in the lower health care expenditure ratios when people aged 20 to 25 years are included in the calculations. See Supplementary Exhibits in Manuel et al.[11]	↓ The size of the effect is difficult to estimate, but it **likely represents less than 5% of total expenditures**, given that 10% of expenditures are provided to people under the age of 20 years and for many of whom, there is low or no prevalence of smoking.
Overall assumption: recent health surveys that ask respondents about their lifetime history of smoking can be used to generate the historic and future smoking status of Canadians.	CCHS surveys allow for the creation of life histories of smoking at the individual level for a representative sample of Ontarians. These histories can be applied to an APC model to estimate initiation and cessation rates for each sex/age/year combination of survey respondents. By applying the APC effects to future time periods, we can represent future status.		↑ or ↓

EXHIBIT A-5 *Continued*

Assumption/Approach	Description	Effect on Findings	Summary Effect on SAE Projections*
How was smoking prevalence estimated?			
Community-dwelling Ontarians	Smoking prevalence was measured using surveys of people living in the community setting. For the most part, these surveys **did not include**: - residents of long-term care facilities - people living on First Nations reserves - incarcerated individuals - military personnel	It is difficult to assess the effect of smoking on the APC model, but it is likely small. However, smoking prevalence is high in settings not included in the CCHS. For example, residents of long-term care facilities have high rates of former smoking. Current-smoking prevalence rates are much higher on First Nations reserves and among the incarcerated, compared to the general Ontario population.[25,26] As well, health care expenditures are higher for many of the populations excluded from the surveys. In Ontario, First Nations peoples are covered by standard provincial health insurance plans, and they can bill the federal government for health care benefits not covered by the provincial plans or their workplace health insurance under the Non-Insured Health Benefits Program.[27] Health care for individuals incarcerated in federal prisons is covered by the Correctional Service of Canada. Health care in provincial facilities is administered by the Ontario Ministry of Community Safety and Correctional Services. These expenditures are not captured in this report.	↓ The effect on the SAE of excluding non-community-dwelling people is **likely less than 3% of total expenditures**, given that the excluded population is approximately 2% of the total population,[28] and not all expenditures are paid by the Ontario government.
Self-reported response with respect to smoking status in survey questions	Survey respondents may over-report what they perceive to be healthy behaviours and under-report their unhealthy behaviours; this tendency is referred to as social desirability bias.[29]	SAE estimates will be under-estimated. However, validation of smoking status based on physical measures (e.g., cotinine level in urine) suggests there is minimal under-reporting. According to one study, smoking prevalence is under-reported by approximately 3% (relative difference). [30]	↓ Underreporting of smoking status likely reduced the estimated SAE by approximately 3%, given that smoking prevalence is under-reported by approximately 3%.[30]

EXHIBIT A-5 *Continued*

Assumption/Approach	Description	Effect on Findings	Summary Effect on SAE Projections*
Smokers who started smoking prior to arrival in Canada were not included in the initiation model.	The initiation model reflects only those who were living in Canada at the age of consideration for each step of the model.	Because prevalence rates of current and former smokers were derived from the initiation and cessation models, those who started smoking prior to coming to Canada were not counted as smokers for the years they were in Canada. This may result in an underestimate of smoking prevalence. Among recent immigrants (defined as those in Canada for less than 15 years), smoking prevalence was about 14%.[31]	↓
Initiation was modelled from age 8 years onward and cessation from age 15 years onward.	It is unlikely that individuals would become habitual smokers prior to age 8, and those who initiated and quit smoking prior to age 15 are better considered lifetime non-smokers.	As the population prevalence estimates were based on individuals aged 15 years and older, this should have little to no impact on estimates.	—
Those missing the age of first cigarette were assigned a value through multiple imputation, based on birth year, sex, race and immigration status. Those missing the age of last cigarette were assigned a value through multiple imputation, based on birth year, sex, race, immigration status and age of smoking initiation.	Because we were interested in constructing life histories of smoking, it was necessary to know the age at initiation and cessation. If these were missing from the survey data (as was the case for approximately 1% of initiations and 0.02% of cessations), we used multiple imputation to assign an age.	Because the imputation method, which assigned ages based on factors known to impact initiation and cessation, accounted for the cohort effect and because there were so few missing values, this approach should have minimal to no effect on the estimates.	—
In the initiation and cessation models, the cohort effect was assumed constant from 1985 forward, the period effect of initiation was assumed constant for males from 1999 forward and for females from 2003 forward, and the period effect of cessation was assumed constant from 2013 forward.	Those born after 1985 (i.e., those younger than 18 in 2003) were not included in the estimates. At the time of this study, 2013 was the last year of available data for estimates of initiation and cessation. Choosing fixed rates for initiation after 1999 (for males) or 2003 (for females) provided the best model to fit the historical data.	If younger generations are initiating at a lower rate than previous generations, and if cessation is becoming more common, the current and former prevalence rates will be overestimated.	↑
In the initiation and cessation models, the period effect was assumed constant from 1928 backward and the cohort effect was assumed constant from 1920 backward.	Because the survey years were 2003 to 2013, the number of respondents born prior to 1920 was too small to provide stable estimates. Therefore, constant cohort or period effects were assumed for the earliest period of the study.	To generate population prevalence estimates for 1950 onwards, we needed cohorts dating back to 1880. The model assumed all cohorts from 1880 to 1920 had the same cohort effect for initiation and cessation. If these effects are higher or lower, prevalence estimates may be biased up or down.	↑ or ↓

EXHIBIT A-5 *Continued*

Assumption/Approach	Description	Effect on Findings	Summary Effect on SAE Projections*
Differential mortality of smokers affects age-period initiation rates and age-period ever smoker rates.	Mortality adjustment was applied twice to the estimates: first, in the initiation model to correct for the number of people who started smoking but died prior to survey; second, in the ever smoker formula, to remove the number of smokers presumed deceased from the total population.	The first mortality adjustment raises initiation rates, resulting in an increased ever smoker proportion and subsequent prevalence estimates. The second adjustment mitigates this impact by decreasing the proportion of ever smokers. If these adjustments are inadequate or imbalanced, prevalence estimates may be biased up or down.	↑ or ↓
The mortality hazard ratio for smokers versus non-smokers was considered constant for a given age across all periods.	The mortality adjustment applied to ever smokers is based on MPoRT estimates of one-year hazard for each age and sex—period effects were not accounted for in the hazard ratio. However, mortality adjustment did consider the intensity of smoking, including the adjustment for years since quitting, which varied over periods.	Since differential mortality between smokers and non-smokers may have been greater for older periods, a greater proportion of the ever smokers would have died earlier and the study approach would overestimate current/former prevalence.	↑
Sociodemographic position was ascertained using highest obtained education.	Education was considered a lifetime proxy of sociodemographic position for smoking prevalence estimates by sociodemographic position. However, the concept of sociodemographic position and its influence on smoking likely varied considerably over birth cohorts from 1920 to current time.	Education likely has varying representation of sociodemographic positon across birth cohorts. For example, a person born in 1920 whose highest education was high school graduation may reflect different sociodemographic influences on smoking compared to recent birth cohorts.	
Cost ratios			
Overall assumption: The increased ratio of health care expenditures for smokers compared to non-smokers can be estimated using health surveys (CCHS) linked at the individual level to health care use.			↑ or ↓

EXHIBIT A-5 *Continued*

Assumption/Approach	Description	Effect on Findings	Summary Effect on SAE Projections*
Health expenditure ratios were obtained from a separate report using multivariable adjustment of confounding.[13]	The same or similar data were used to estimate expenditure ratios. Estimates of expenditure ratios are subject to many of the same limitations as already identified. Unmeasured confounding is possible, as well as the potential for expenditure ratios to be over-adjusted for confounding or mediation.	The expenditure ratios could be too low or too high. Confounding can result in an important level of bias. The relationship between smoking and health care expenditures has a range of potential confounders. All confounders were self-reported, and measurement error of confounders was present. 'Overmatching' and/or inclusion of mediators can also result in an important level of bias. These considerations are like those for confounding.	↑ or ↓ to ↑↑↑ or ↓↓↓ The potential bias from confounding and inclusion of mediators can be gauged by examining the range of health expenditure ratios in the Ten-Year Impact Study.[3] In that study, health expenditure ratios for smoking and subsequent SAEs varied by approximately 20%.
Cost ratios remain constant over the 38-year period of this study.	We used cost ratios from a previous report.[3] These cost ratios reflect the average over a ten-year timeframe (2004 to 2013). The timeframe for the current study is longer.	Historically, smoking intensity was higher than in recent years. The current smoking cost ratios may underestimate historic periods and, conversely, over estimate projected periods if smoking intensity continues to decline. As well, given the longer timeframe of this study, duration of smoking abstinence may not be adequately accounted for in the former smoking cost ratios.	↑ or ↓
Health care expenditure projections			
Health care expenditures are limited to those health sectors that are government-funded. Missing are nongovernment expenditures and expenditures by government that are not health-related.	Private expenditures related to smoking are not captured in this study, nor are costs for lost productivity, secondhand smoke, smoking prevention research, etc.	Since social costs are not estimated, the total burden of smoking will be underestimated.	↓
Direct impact examined	Missing from estimates are SAEs for non-smokers. Examples include injuries due to tobacco-related fires, lung cancer attributed to secondhand exposure, and adverse birth outcomes (e.g., premature birth) attributable to mothers who smoke.	SAE estimates for smoking will be underestimated. Indirect SAEs were not included.	↓ The effect of excluding indirect smoking effects likely reduced the estimated SAE. The size of the effect is difficult to estimate.

EXHIBIT A-5 *Continued*

Assumption/Approach	Description	Effect on Findings	Summary Effect on SAE Projections*
Out-of-province hospital expenditures	Starting in FY 1979, the Public Accounts included expenditures related to "Out-of-province Hospital Services" in the line item "Payments made for care provided by physicians and practitioners under the Ontario Health Insurance Plan." Using the Public Accounts alone, it was not possible to extract this amount from expenditures included in community care.	Expenditures in community care will be higher and expenditures in additional health care expenditures will be lower. The community care AFP was used for additional health care expenditures. As the proportion of expenditures for individuals younger than age 20 (i.e., excluded expenditures) is higher for community care than for additional health care, the SAE will be underestimated.	↓ The total provincial SAE will be underestimated. Because out-of-province expenditures are small (approximately 3% of OHIP expenditures in FYs 1983 to 1986), the impact on SAE will be a fraction of this.
Ontario Drug Benefit (ODB) Plan	In FY 1998, the Public Accounts began reporting aggregated data for "Ontario Drug Programs." Using the Public Accounts alone, it is not possible to extract ODB expenditures from the total amount spent on drug programs.	Drugs expenditure will be higher and additional health care expenditures will be lower. Drugs has a higher AFP than additional health care expenditures and the amount excluded from drugs (i.e., for individuals younger than age 20) is lower than the amount excluded in additional health care expenditures. Thus, the SAE for drugs is overestimated and the SAE for additional health care expenditures is underestimated, but the overall impact would be an overestimated SAE.	↑ This is difficult to quantify; the AFP for drugs is one percentage point higher than the AFP for additional health care expenditures, and the proportion excluded under drugs is six percentage points lower than the proportion excluded from additional health care expenditures. However, given that the ODB program is Ontario's largest drug program (80% of total drug expenditures in FY 2014) and that the amount spent on drugs is the report's smallest expenditure category, the impact on the provincial SAE is expected to be small.
Projected health care expenditures will increase according to historic trends.	Since future health care expenditures are unknown, a quadratic trend was used to predict expenditures from 2017 to 2041.	Actual expenditures may be higher or lower than projected depending on future health care policy (e.g., reduction in hospital funding, expansion of Ontario drug programs).	↑ or ↓
Discount rate			
A discount rate of 1.5% was used for future projected expenditures, as per the 2017 CADTH guidelines.[14]	Future inflation may be higher or lower than the present rate.	Future SAE may be over- or underestimated.	↑ or ↓

*↑ = The reported smoking-attributable health care expenditure (SAE) estimate is likely to be greater than the true or unbiased estimate; ↓ = The smoking-attributable health care expenditure estimate is likely to be less than expected. One arrow = small impact (less than a 5% difference), three arrows = larger impact (more than a 10% difference).
Abbreviations: AFP = attributable fraction in the population; APC = age-period-cohort; CADTH = Canadian Agency for Drugs and Technologies in Health; CCHS = Canadian Community Health Survey; MPoRT = Mortality Population Risk Tool; SAE = smoking-attributable expenditure

EXHIBIT A-6 Historic and projected prevalence of female current smokers, by decade of birth, in Ontario, 1928 to 2041

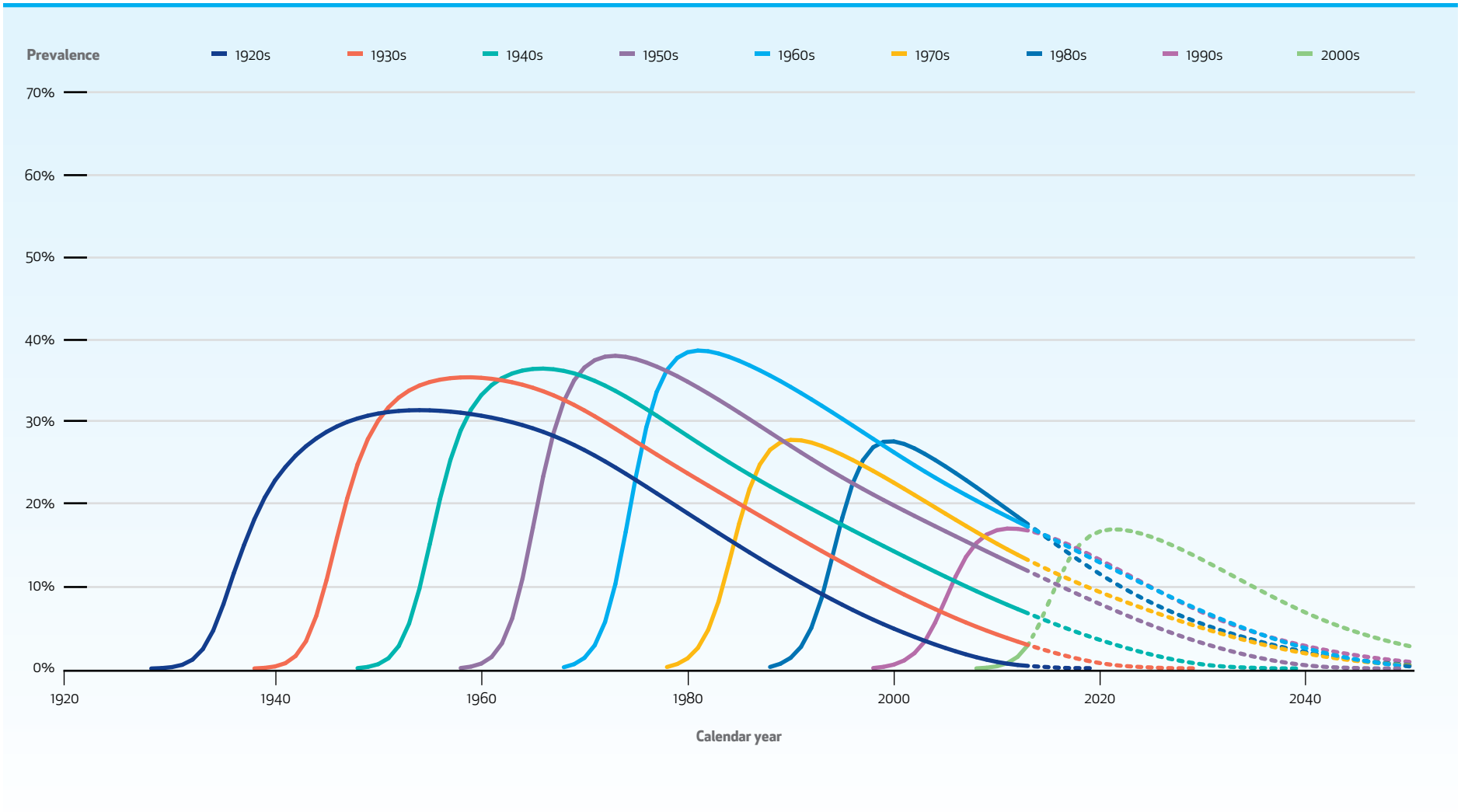


EXHIBIT A-7 Historic and projected prevalence of male current smokers, by decade of birth, in Ontario, 1928 to 2041

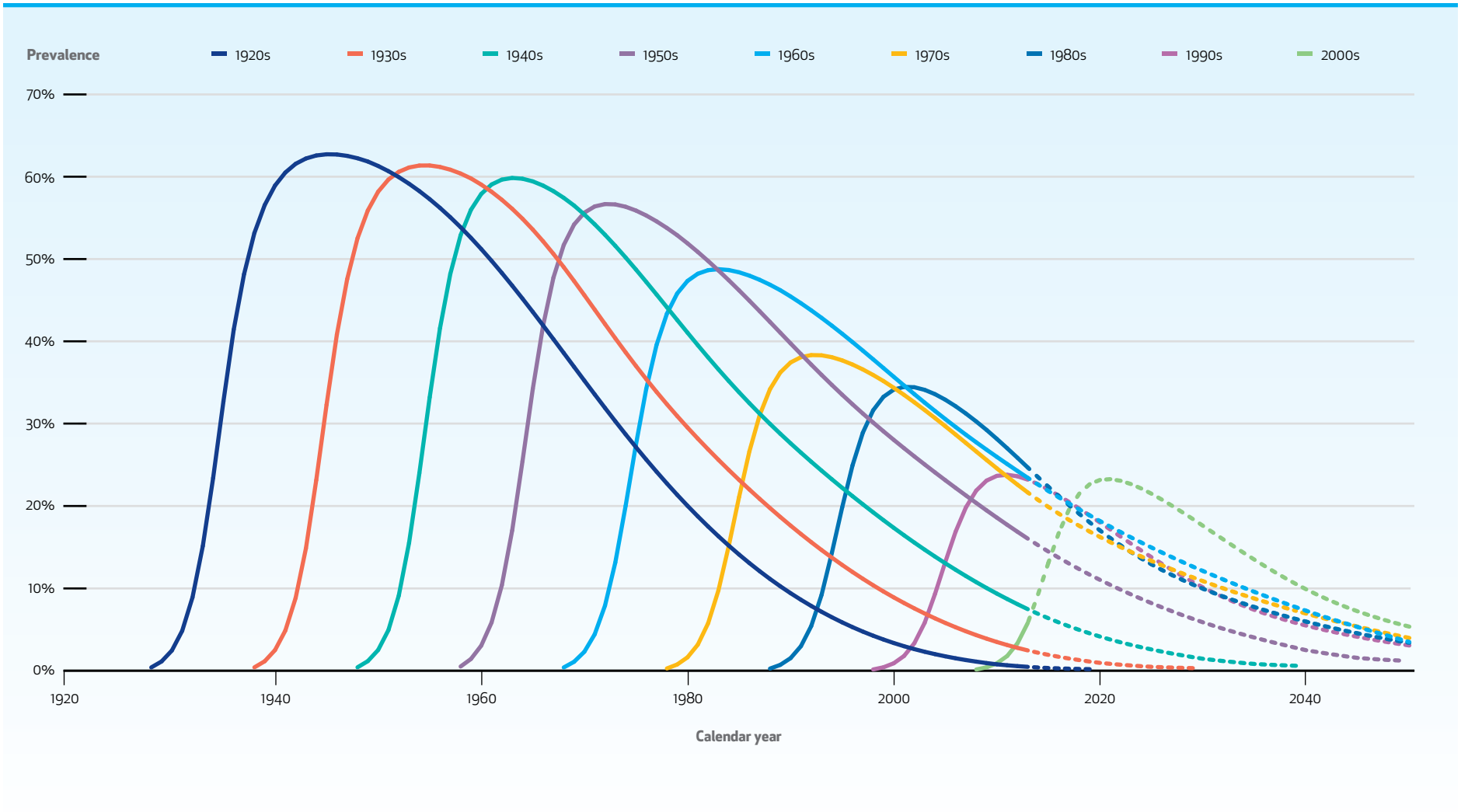


EXHIBIT A-8 Historic and projected prevalence of female former smokers, by decade of birth, in Ontario, 1928 to 2041

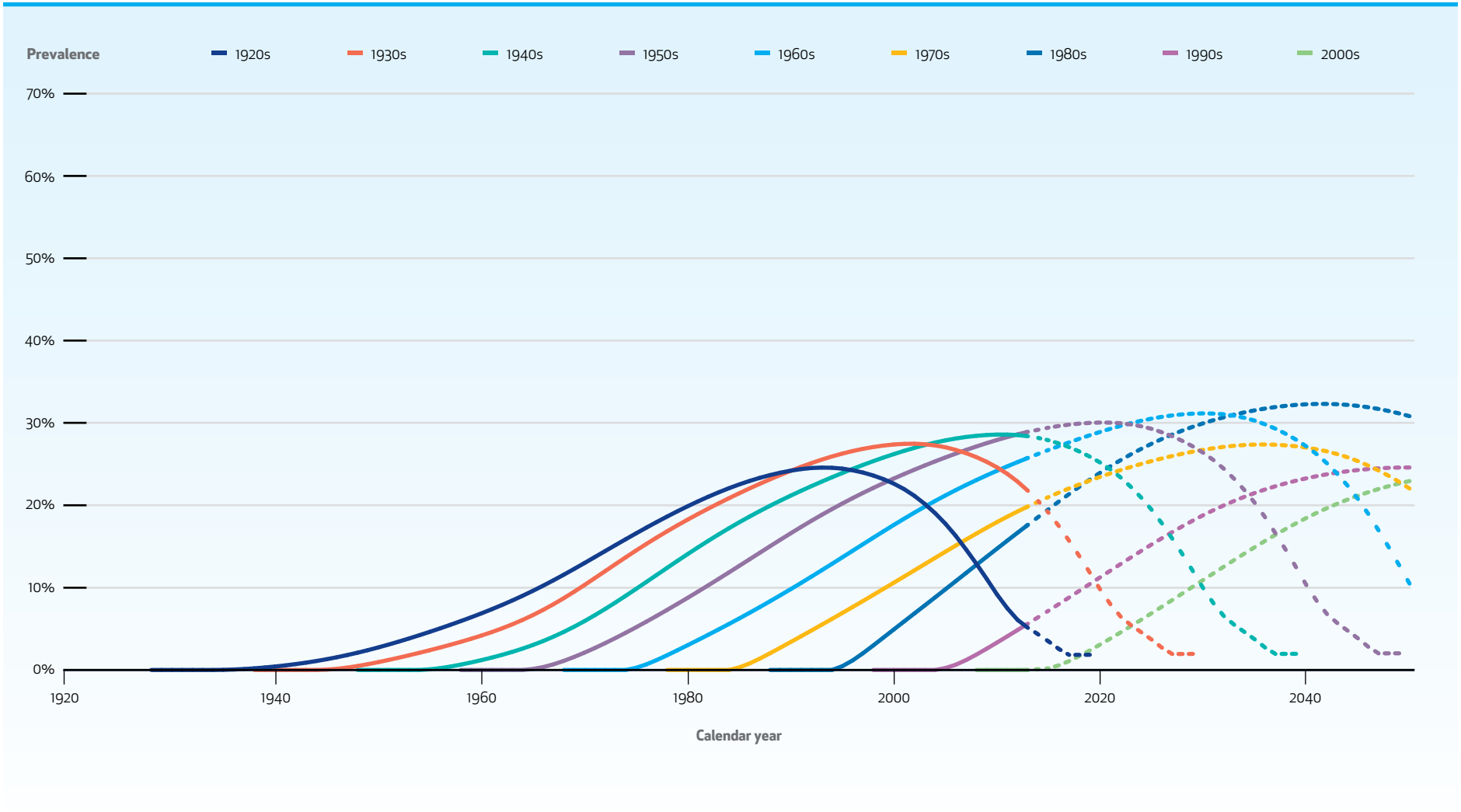


EXHIBIT A-9 Historic and projected prevalence of male former smokers, by decade of birth, in Ontario, 1928 to 2041

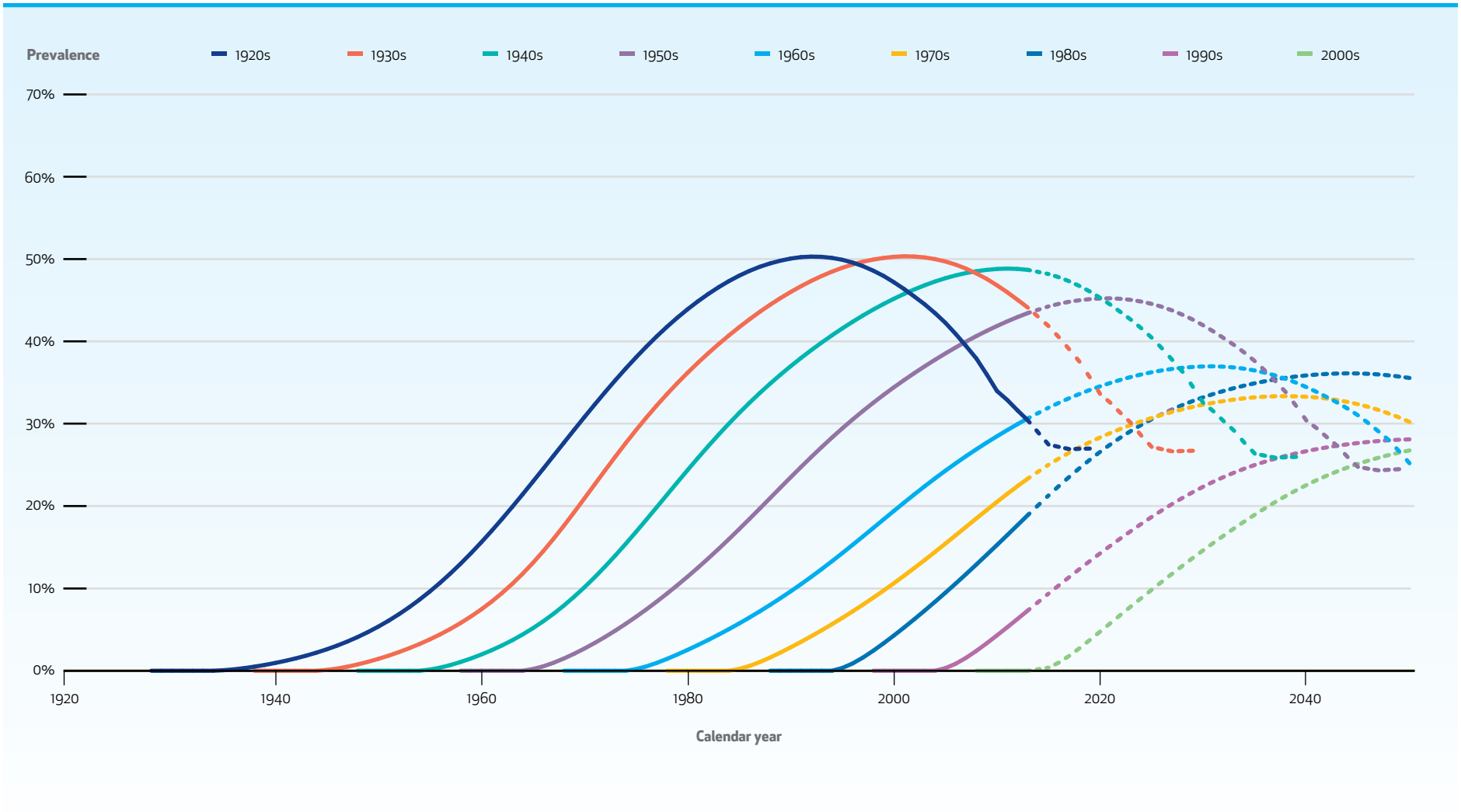


EXHIBIT A-10 Probability of female smoking initiation, by age and decade of birth, in Ontario, 1920s to 1980s

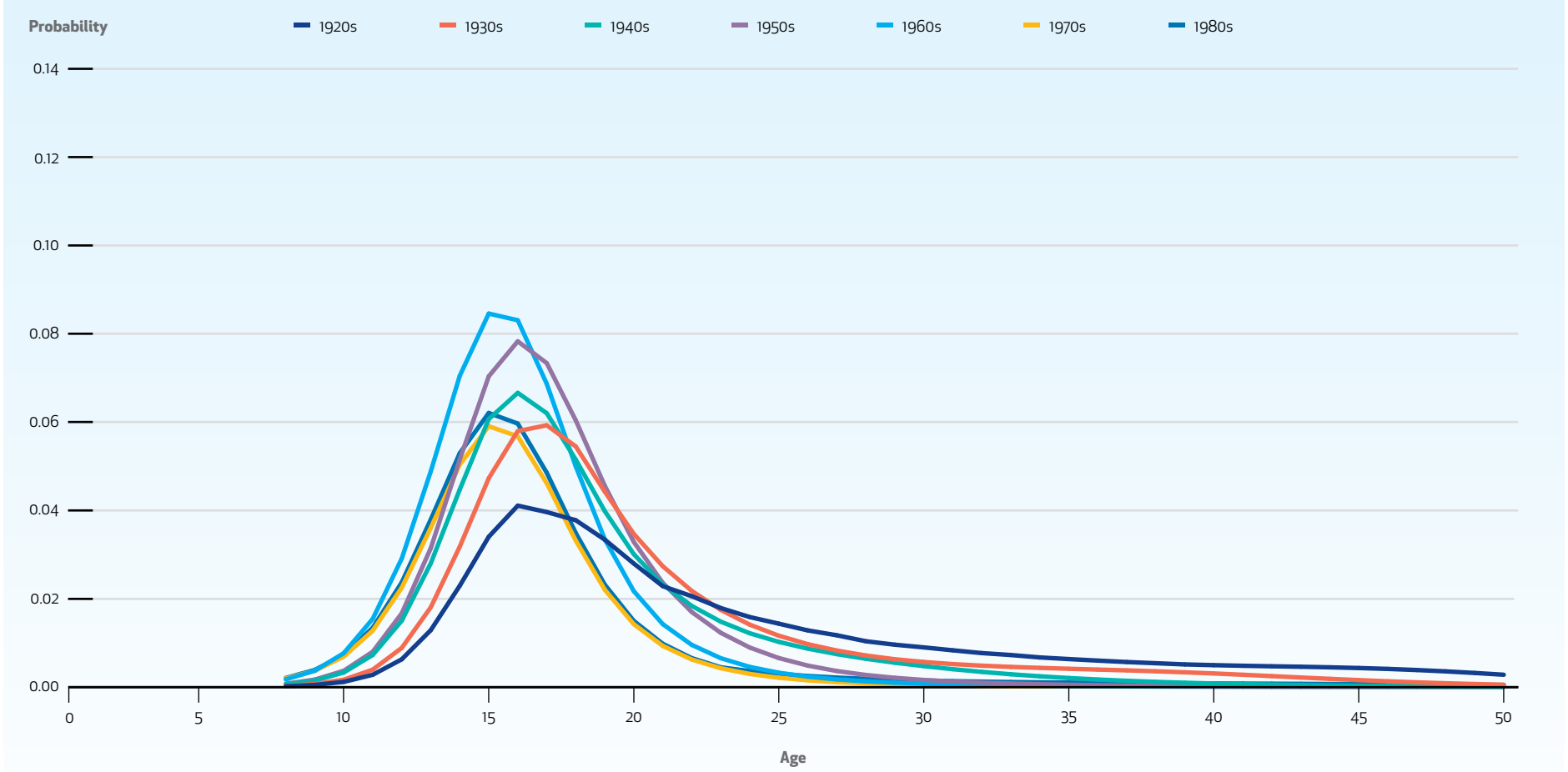


EXHIBIT A-11 Probability of male smoking initiation, by age and decade of birth, in Ontario, 1920s to 1980s

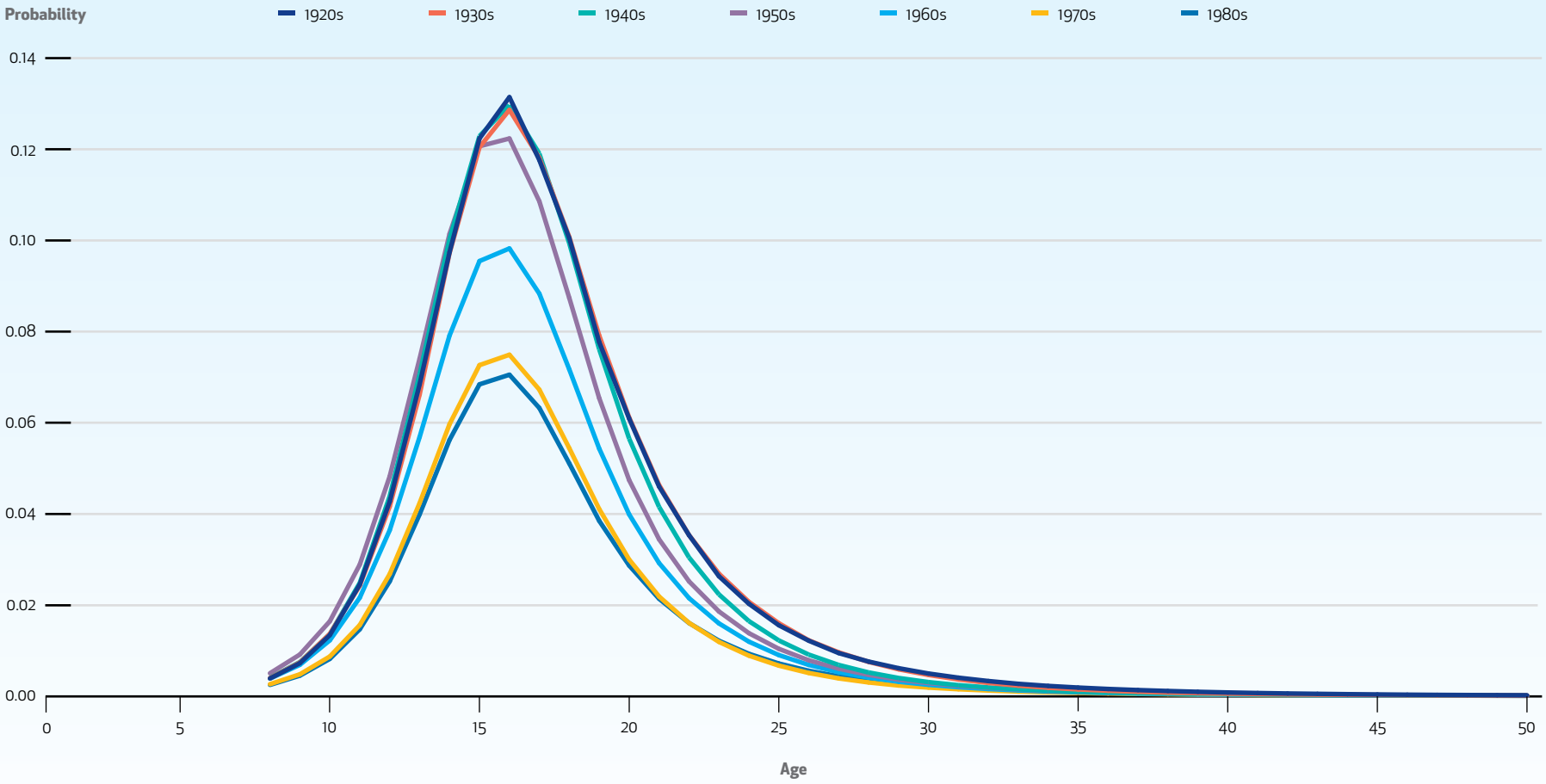


EXHIBIT A-12 Probability of female smoking cessation, by age and birth cohort, in Ontario, 1920s to 1980s

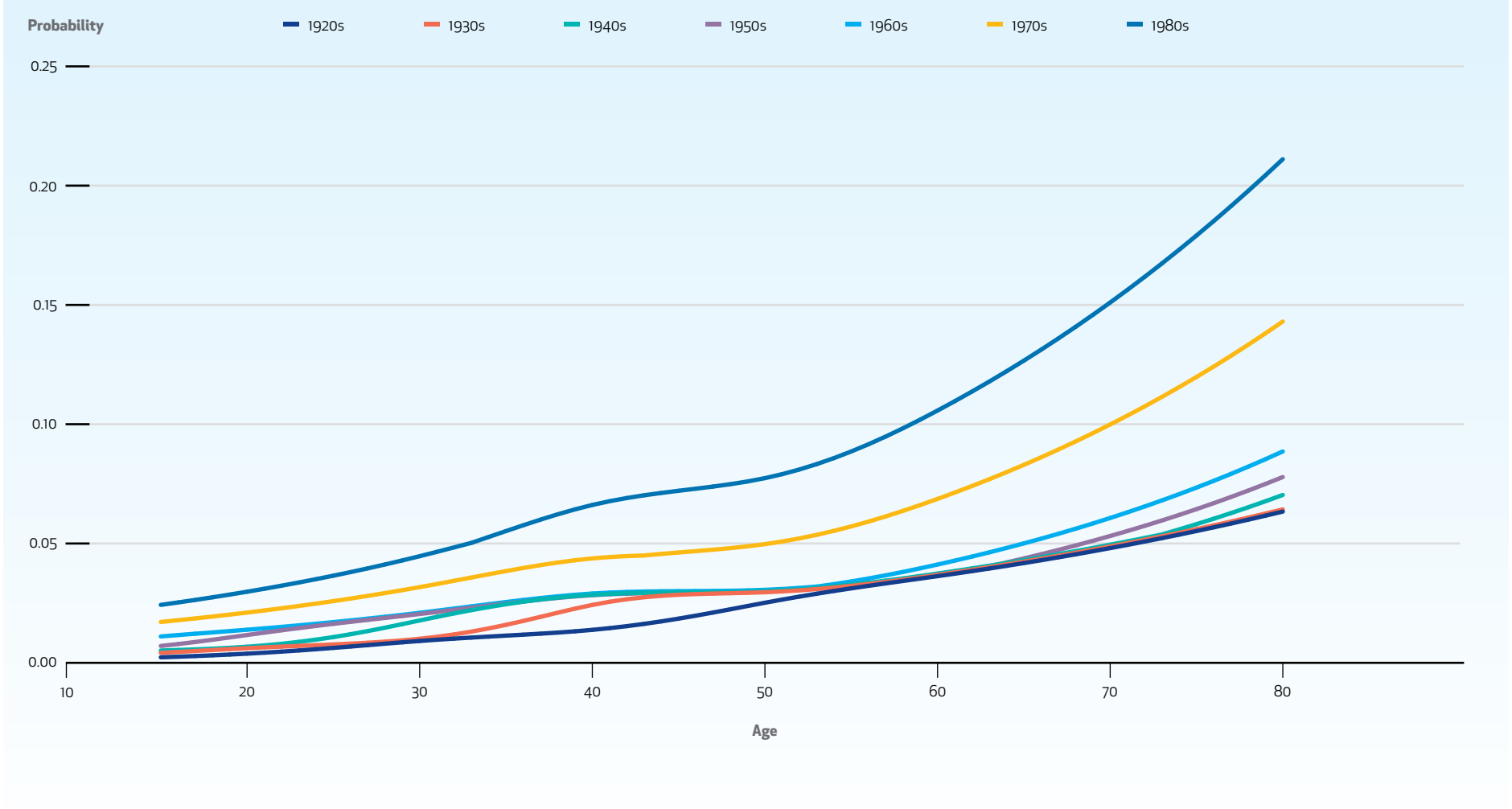


EXHIBIT A-13 Probability of male smoking cessation, by age and birth cohort, in Ontario, 1920s to 1980s

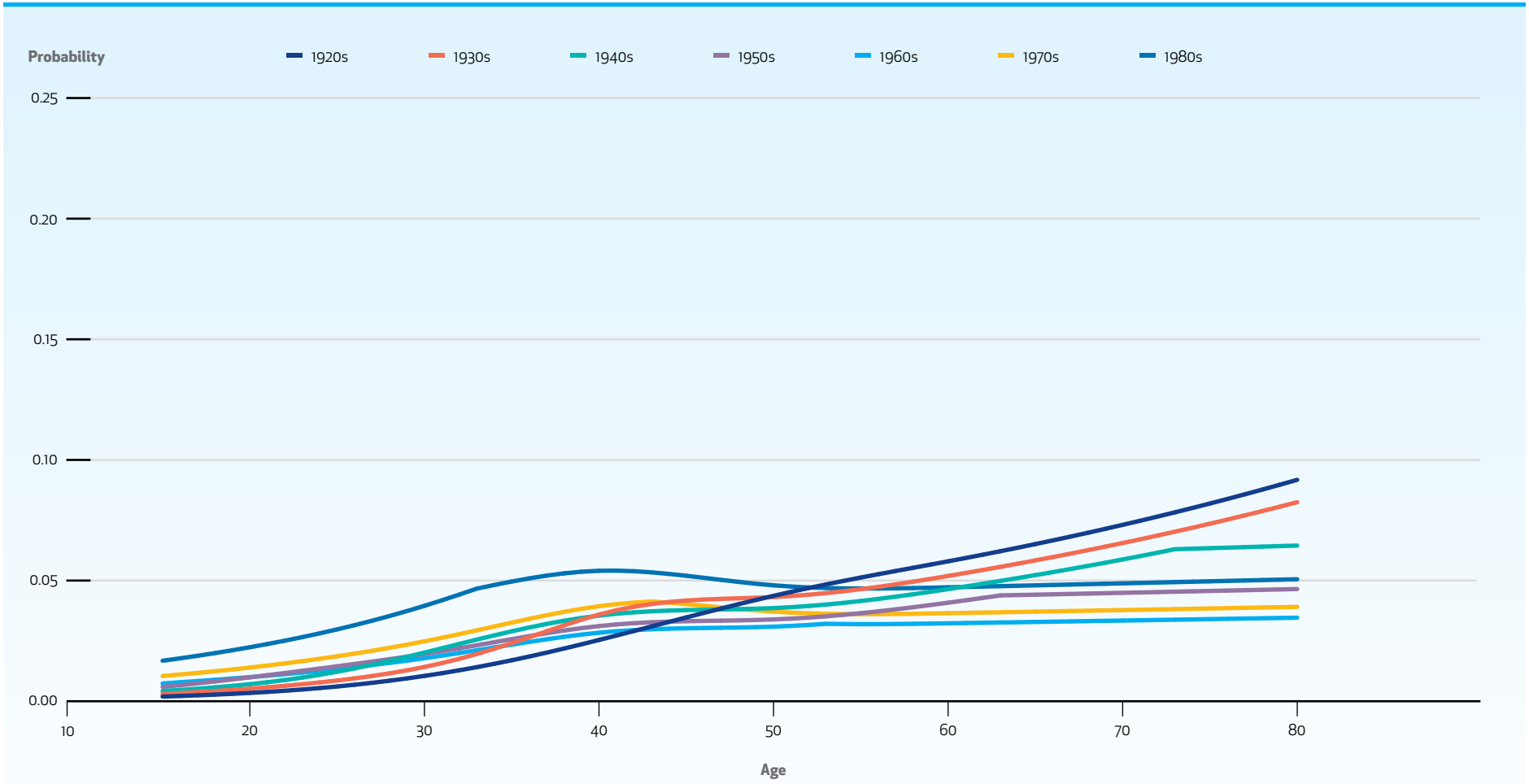


EXHIBIT A-14 Smoking duration among female current smokers, by decade of birth, in Ontario, 1920s to 1980s

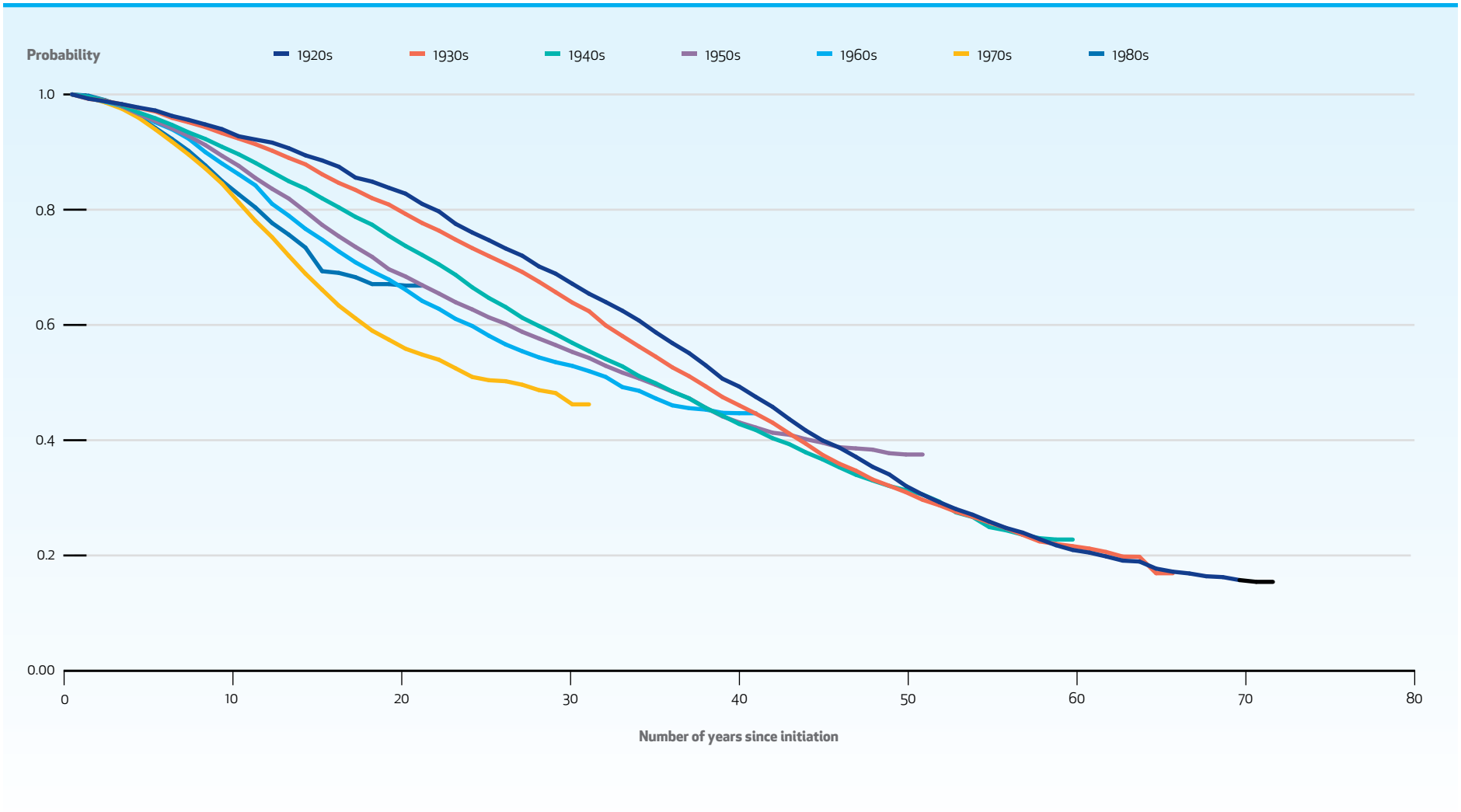


EXHIBIT A-15 Smoking duration among male current smokers, by decade of birth, in Ontario, 1920s to 1980s

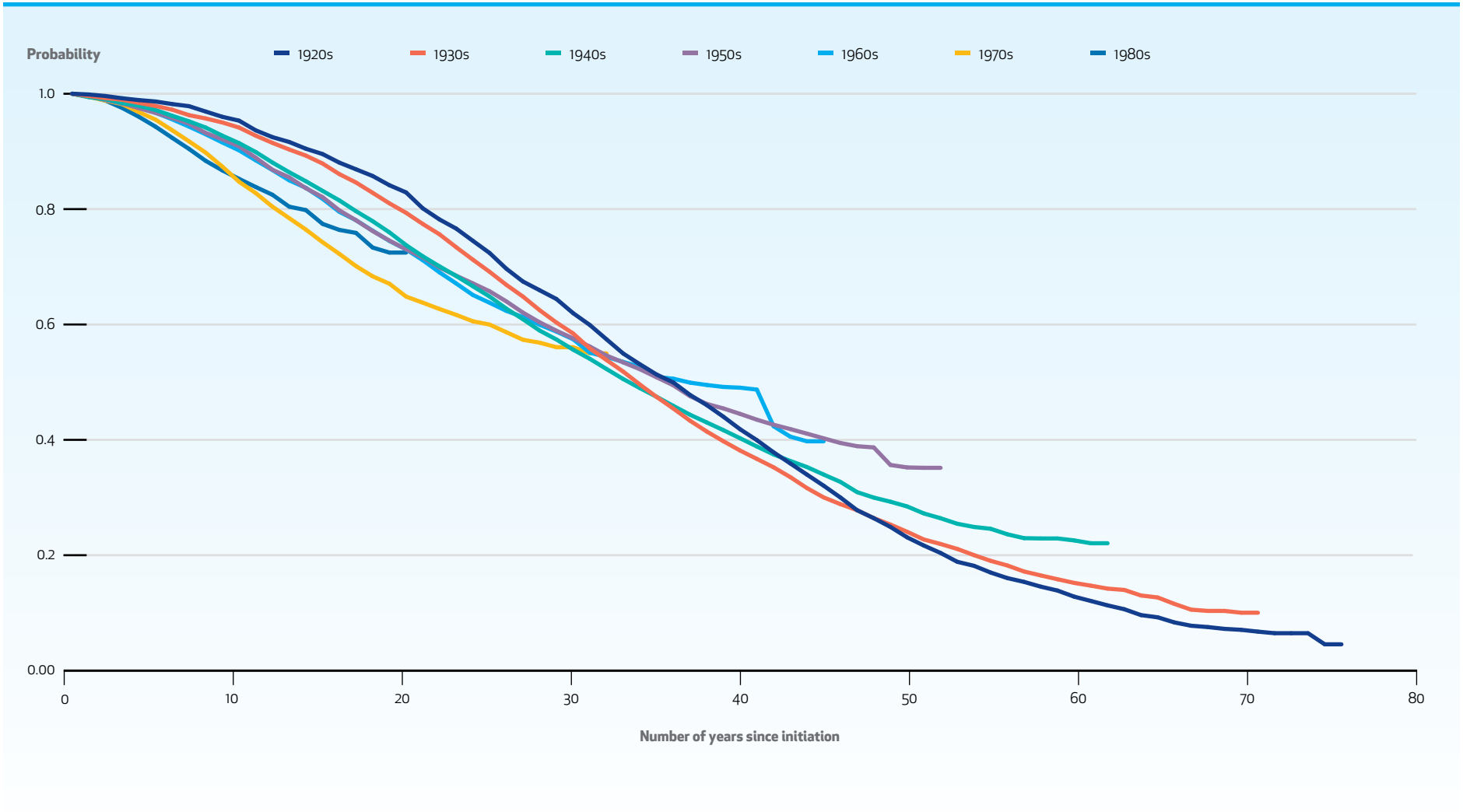


EXHIBIT A-16.1 Comparison of modelling approaches for sociodemographic position: historic and projected prevalence of female current smokers, by level of education, in Ontario, 1971 to 2041

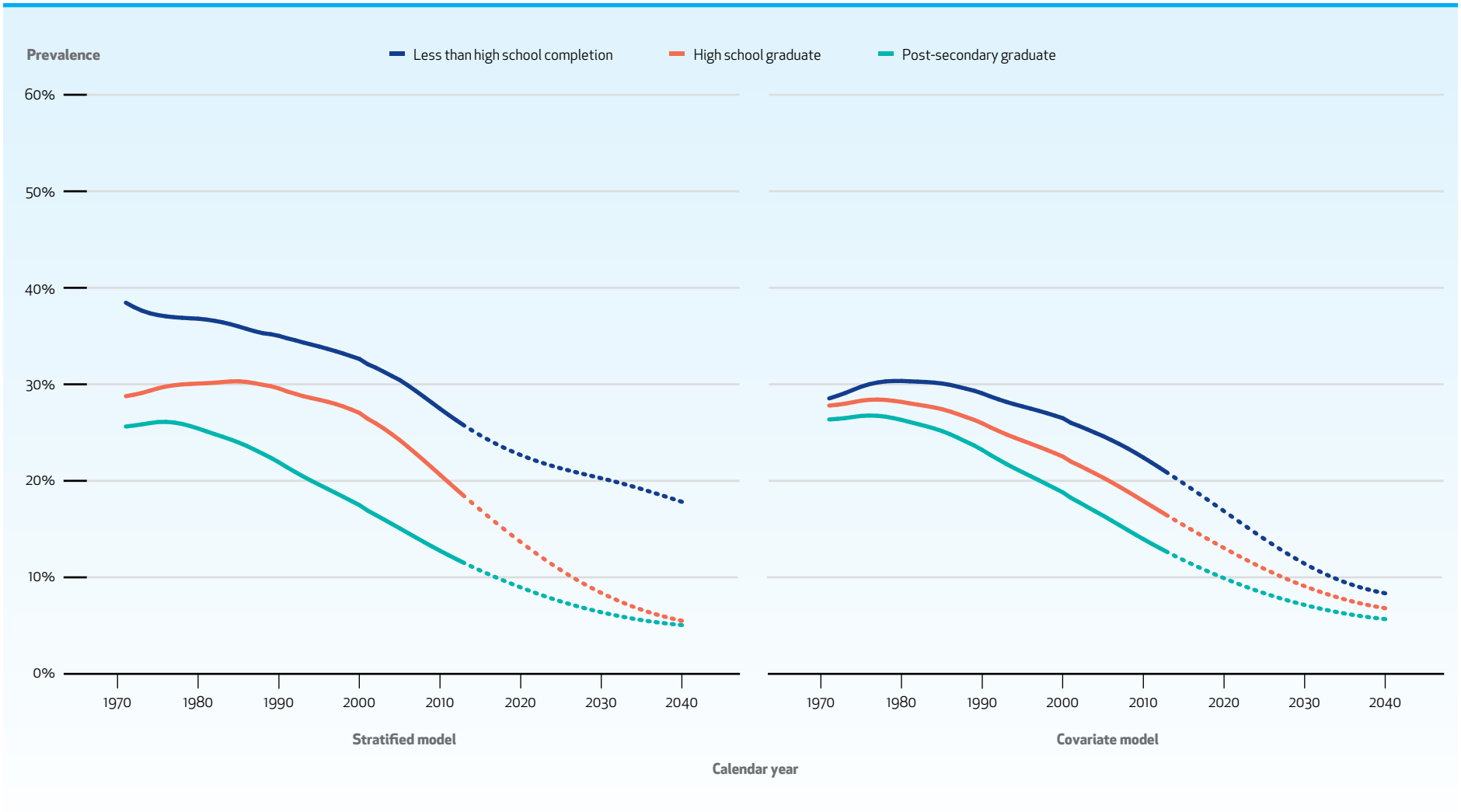


EXHIBIT A-16.2 Comparison of modelling approaches for sociodemographic position: historic and projected prevalence of female former smokers, by level of education, in Ontario, 1971 to 2041

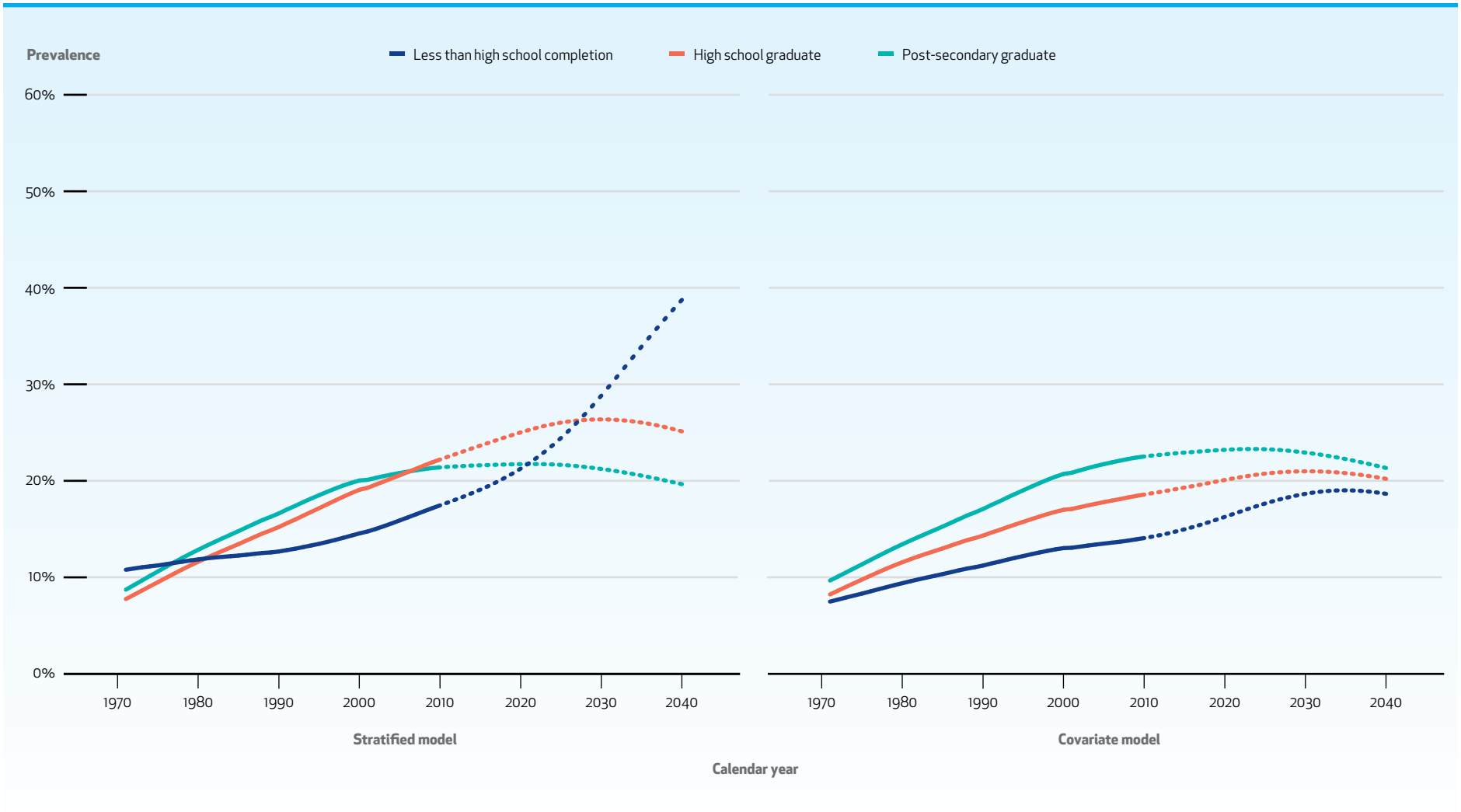


EXHIBIT A-17.1 Comparison of modelling approaches for sociodemographic position: historic and projected prevalence of male current smokers, by level of education, in Ontario, 1971 to 2041

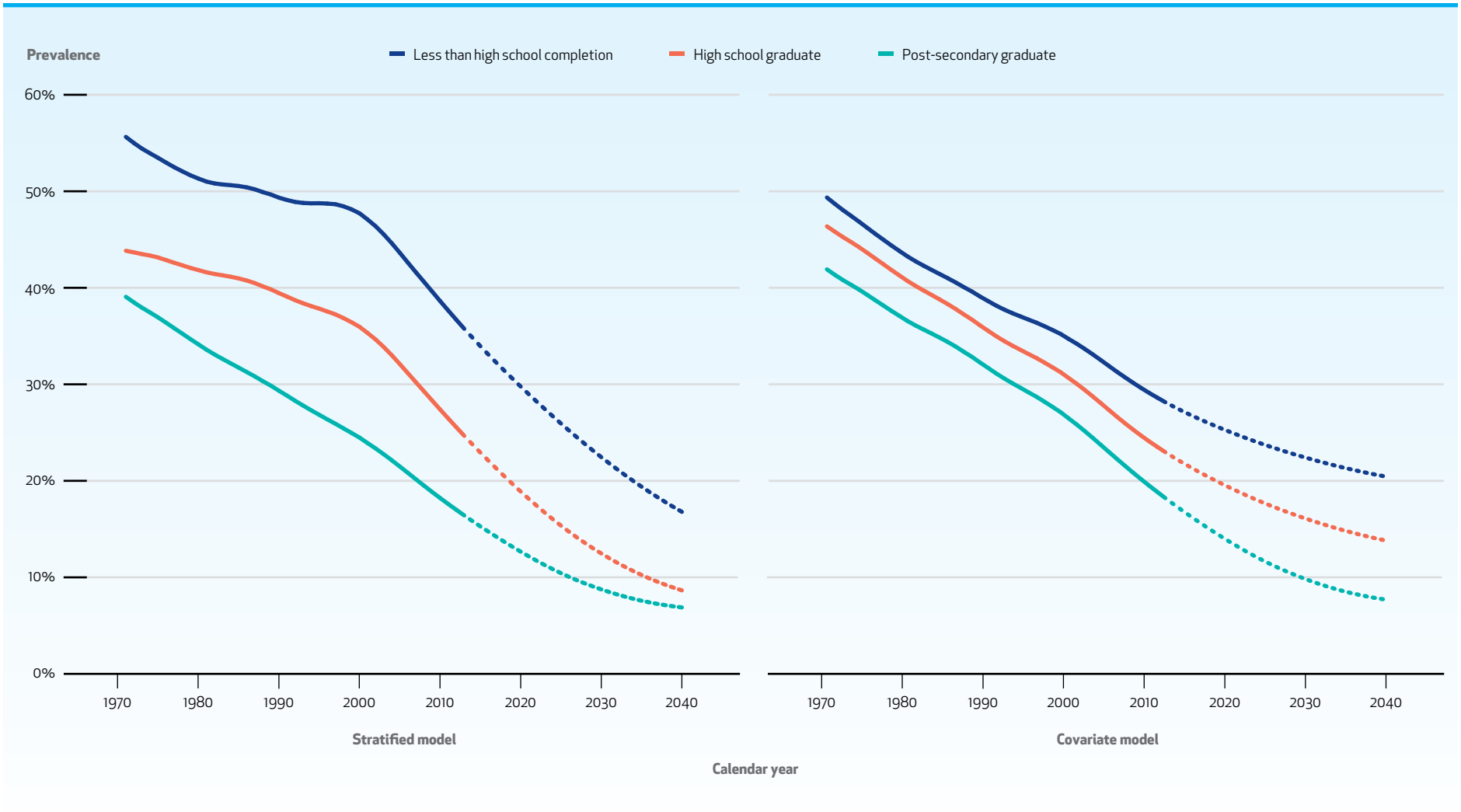
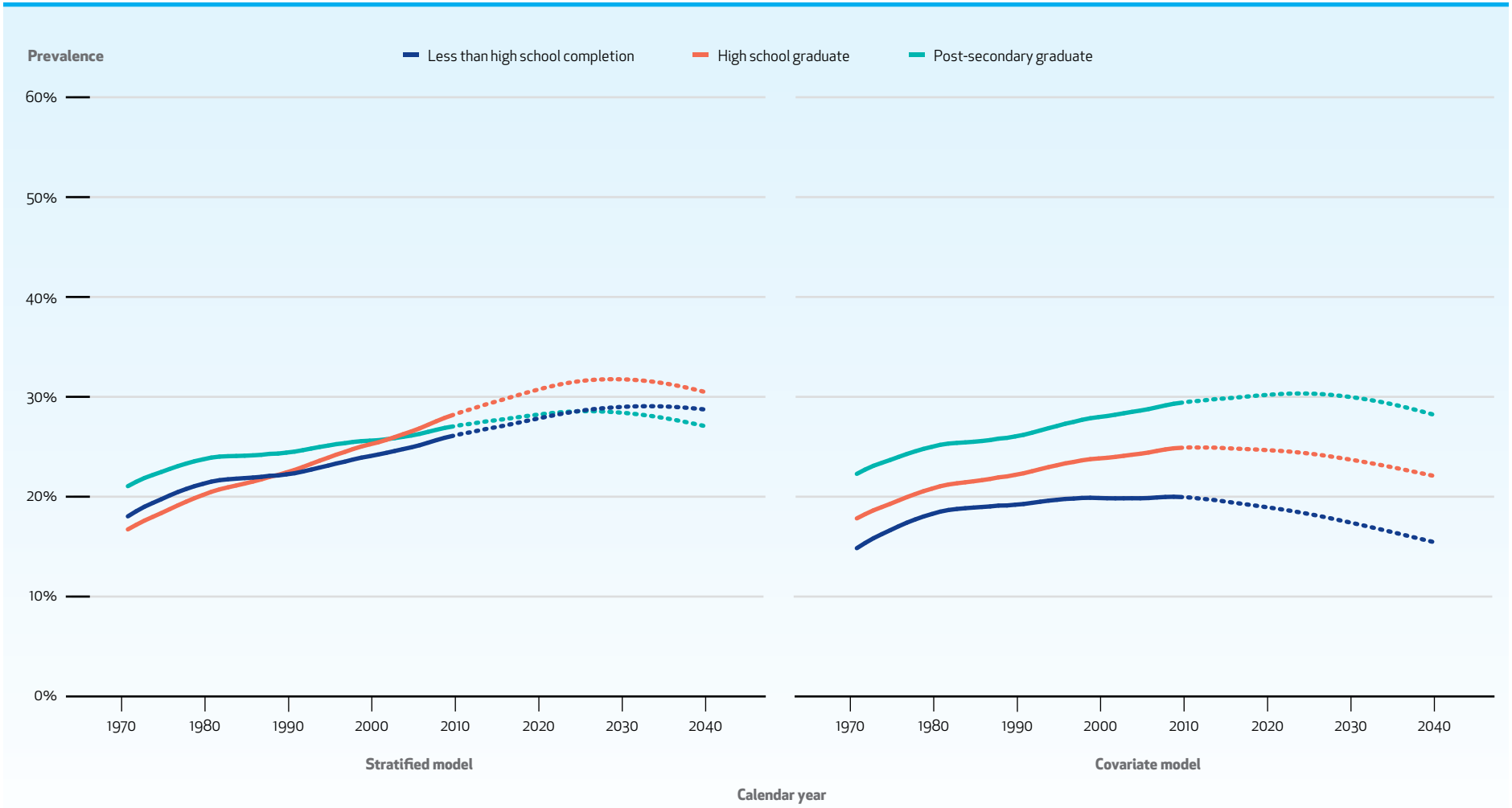


EXHIBIT A-17.2 Comparison of modelling approaches for sociodemographic position: historic and projected prevalence of male former smokers, by level of education, in Ontario, 1971 to 2041



References

1. World Health Organization. *WHO Report on the Global Tobacco Epidemic, 2011: Warning About the Dangers of Tobacco*. Geneva: WHO; 2011. Accessed May 1, 2018 at **http://whqlibdoc.who.int/publications/2011/9789240687813_eng.pdf**.

2. Dobrescu A, Bhandari A, Sutherland G, Dinh T. *The Costs of Tobacco Use in Canada*, 2012. Ottawa, ON: The Conference Board of Canada; 2017.

3. Manuel DG, Perez R, Bennett C, Laporte A, *Wilton AS, Gandhi S, Yates EA, Henry DA. A $4.9 Billion Decrease in Health Care Expenditure: The Ten-Year Impact of Improving Smoking, Alcohol, Diet and Physical Activity in Ontario*. Toronto, ON: Institute for Clinical Evaluative Sciences; 2016. Accessed May 1, 2018 at **https://www.ices.on.ca/~/media/Files/Atlases-Reports/2016/The-Ten-Year-Impact-of-Improving-Smoking-Alcohol-Diet-and-Physical-Activity-in-Ontario/Full-Report.ashx**.

4. Ontario Ministry of Health and Long-Term Care. *Patients First: Action Plan for Health Care*. Toronto, ON: Queen's Printer for Ontario; 2015. Accessed May 1, 2018 at **http://www.health.gov.on.ca/en/ms/ecfa/healthy_change/docs/rep_patientsfirst.pdf**.

5. Hennessy DA, Flanagan WM, Tanuseputro P, Bennett C, Tuna M, Kopec J, Wolfson MC, Manuel DG. The Population Health Model (POHEM): an overview of rationale, methods and applications. *Popul Health Metr.* 2015; 13:24.

6. Office of the Auditor General of Ontario. Public accounts of the province. In: *2012 Annual Report*. Toronto, ON: Queen's Printer for Ontario; 2012; 27-44.

7. Ontario Hospital Services Commission. *Annual Statistical Report on Public and Private Hospitals*, 1959 to 1972. Toronto, ON: OHSC; 1972.

8. Deber RB, Mah CL, editors. *Case Studies in Canadian Health Policy and Management*. 2nd ed. Toronto, ON: University of Toronto Press; 2014.

9. Ontario Ministry of Health. *1974-75 Annual Report*. Toronto, ON: Queen's Printer for Ontario; 1975.

10. Caron-Malenfant E, Coulombe S. *Demosim: An Overview of Methods and Data Sources*. Ottawa, ON: Statistics Canada; 2015. Accessed May 1, 2018 at **http://www.statcan.gc.ca/pub/91-621-x/91-621-x2015001-eng.pdf**.

11. Manuel DG, Perez R, Bennett C, Laporte A, Wilton AS, Gandhi S, Yates EA, Henry DA. *A $4.9 Billion Decrease in Health Care Expenditure: The Ten-Year Impact of Improving Smoking, Alcohol, Diet and Physical Activity in Ontario. Supplementary Exhibits*. Toronto, ON: Institute for Clinical Evaluative Sciences; 2016. Accessed May 1, 2018 at **https://www.ices.on.ca/~/media/Files/Atlases-Reports/2016/The-Ten-Year-Impact-of-Improving-Smoking-Alcohol-Diet-and-Physical-Activity-in-Ontario/Supplementary-Exhibits.ashx**.

12. Manuel DG, Perez R, Sanmartin C, Taljaard M, Hennessy D, Wilson K, Tanuseputro P, Manson H, Bennett C, Tuna M, Fisher S, Rosella LC. Measuring burden of unhealthy behaviours using a multivariable predictive approach: life expectancy lost in Canada attributable to smoking, alcohol, physical inactivity, and diet. *PLoS Med*. 2016; 13(8):e1002082.

13. Statistics Canada. Pohem (Population Health Model). Accessed May 1, 2018 at **https://www.statcan.gc.ca/eng/microsimulation/modgen/new/mods/pohem**.

14. Canadian Agency for Drugs and Technologies in Health. *Guidelines for the Economic Evaluation of Health Technologies: Canada*. 4th ed. Ottawa, ON: CADTH; 2017.

15. Holford TR, Levy DT, McKay LA, Clarke L, Racine B, Meza R, Land S, Jeon J, Feuer EJ. Patterns of birth cohort-specific smoking histories, 1965-2009. *Am J Prev Med*. 2014; 46(2):e31-7.

16. Rose G. Sick individuals and sick populations. *Int J Epidemiol*. 1985; 14(1):32-8.

17. Ontario Ministry of Health and Long-Term Care. *Ontario's Action Plan for Health Care*. Toronto, ON: Queen's Printer for Ontario; 2012. Accessed May 1, 2018 at **http://www.health.gov.on.ca/en/ms/ecfa/healthy_change/docs/rep_healthychange.pdf**.

18. Segal HD. *Finding a Better Way: A Basic Income Pilot Project for Ontario*. Toronto, ON: 2016. Accessed May 1, 2018 at **https://files.ontario.ca/discussionpaper_nov3_english_final.pdf**.

19. Martens P, Nickel N, Forget E, Lix L, Turner D, Prior H, Walld R, Soodeen RA, Rajotte L, Ekuma O. *The Cost of Smoking: A Manitoba Study*. Winnipeg, MB: Manitoba Centre for Health Policy; 2015. Accessed May 1, 2018 at **http://mchp-appserv.cpe.umanitoba.ca/reference/Cost_Smoking_final.pdf**.

20. U.S. Department of Health and Human Services. *The Health Consequences of Smoking – 50 Years of Progress: A Report of the Surgeon General*. Rockland, MD: USDHHS; 2014. Accessed May 1, 2018 at **https://www.surgeongeneral.gov/library/reports/50-years-of-progress/full-report.pdf**.

21. Carter BD, Abnet CC, Feskanich D, Freedman ND, Hartge P, Lewis CE, Ockene JK, Prentice RL, Speizer FE, Thun MJ, Jacobs EJ. Smoking and mortality – beyond established causes. *N Engl J Med*. 2015; 372(7):631-40.

22. Duchman KR, Gao Y, Pugely AJ, Martin CT, Noiseux NO, Callaghan JJ. The effect of smoking on short-term complications following total hip and knee arthroplasty. *J Bone Joint Surg Am*. 2015; 97(13):1049-58.

23. Kenkel DS, Lillard DR, Mathios AD. Accounting for misclassification error in retrospective smoking data. *Health Econ*. 2004; 13(10): 1031-44.

24. Gagne T. Estimation of smoking prevalence in Canada: Implications of survey characteristics in the CCHS and CTUMS/CTADS. *Can J Public Health*. 2017; 108(3):e331-4.

25. Marrett LD, Chaudhry M. Cancer incidence and mortality in Ontario First Nations, 1968-1991 (Canada). *Cancer Causes Control*. 2003; 14(3):259-68.

26. Baybutt M, Ritter C, Stover H. Tobacco use in prison settings: a need for policy implementation. In: *Prison Health Guide*. Geneva: World Health Organisation; 2012; pp. 138-47.

27. Chiefs of Ontario. *A Guide for First Nations in Ontario: Navigating the Non-Insured Health Benefits and Ontario Health Programs Benefits*. Toronto, ON: COO; 2017. Accessed October 20, 2017 at **http://health.chiefs-of-ontario.org/sites/default/files/files/Updated%20Guide%20-%2002-16-2017.pdf**.

28. Beland Y. Canadian community health survey – methodological overview. *Health Rep*. 2002; 13(3):9-14.

29. Kreuter F, Presser S, Tourangeau R. Social desirability bias in CATI, IVR and Web surveys: the effects of mode and question sensitivity. *Public Opin Q*. 2008; 72(5):847-65.

30. Wong SL, Shields M, Leatherdale S, Malaison E, Hammond D. Assessment of validity of self-reported smoking status. *Health Rep*. 2012; 23(1):47-53.

31. Chiu M, Austin PC, Manuel DG, Tu JV. Cardiovascular risk factor profiles of recent immigrants vs long-term residents of Ontario: a multi-ethnic study. *Can J Cardiol*. 2012; 28(1):20-6.

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