

# Budget impact analysis of adopting primary care-based COPD case detection in the Canadian general population

## Contents

<b>Appendix 1A: EPIC validation</b> .....	2
<b>Appendix 1B: Recalibrating the cost-effectiveness plane</b> .....	6
<b>Appendix 1C: Budget impact results tables</b> .....	7
<b>Appendix 1D: Overdiagnosis results</b> .....	12
<b>Appendix 1E: Additional sensitivity analysis results</b> .....	13
<b>Upper age limit</b> .....	<b>Error! Bookmark not defined.</b>
<b>References</b> .....	15

## Appendix 1A: EPIC validation

The Evaluation Platform in COPD (EPIC) is a previously developed model and has undergone rigorous validation including replicating the rate and severity of exacerbations and COPD-related mortality rate in two external cohort studies. Details have been previously described elsewhere (1,2). Below we summarise the key elements relevant to the budget impact analysis.

Population size and demographics are based on population projections from Statistics Canada (3).

Figure 1 shows results of the validation of population size and Figure 2 shows the population pyramid for 2025, near the end of the study time horizon.

Within EPIC, patients can be diagnosed with COPD outside of case detection. The diagnosis module uses input data from the Canadian Cohort of Obstructive Lung Disease (CanCOLD) study to model the annual probability of routine diagnosis during primary care visits both among COPD patients and non-COPD patients (overdiagnosis) (2,4). Probability of diagnosis is modelled as a function of sex, symptoms, smoking status, and number of GP visits. The diagnosis module has been calibrated to yield a stable proportion of diagnosed patients among COPD individuals approximately equal to that observed in CanCOLD (29.7%) (5,4). Overdiagnosed patients can have their diagnosis reversed annually, the probability for which is calibrated to yield a stable proportion of false positive diagnoses among non-COPD individuals at 3% in accordance with the observed input CanCOLD data source (2) and similar to

previous studies (6). Figures 3 and 4 shows results of the validation over a 20-year time horizon for 150,000 individuals simulated in EPIC.A

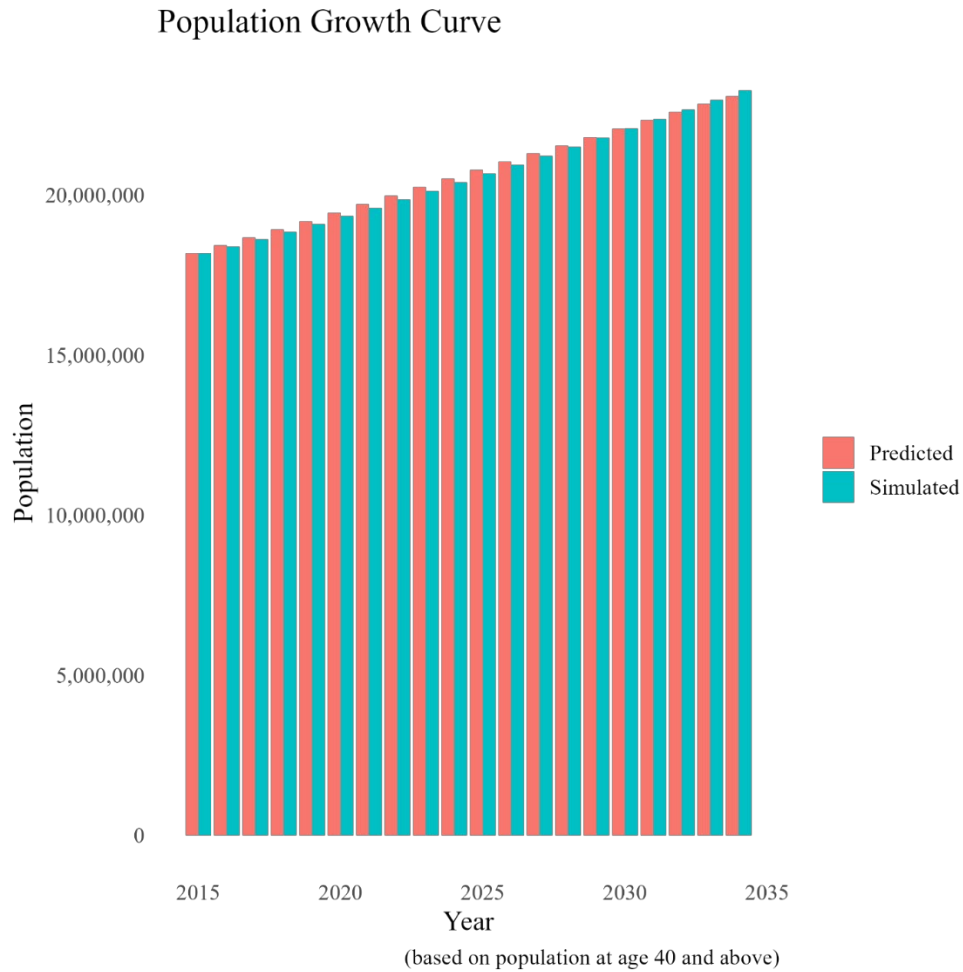


Figure 1: EPIC-simulated population growth compared with population projections between 2015-2035.

## Simulated vs. Predicted Population Pyramid in 2025

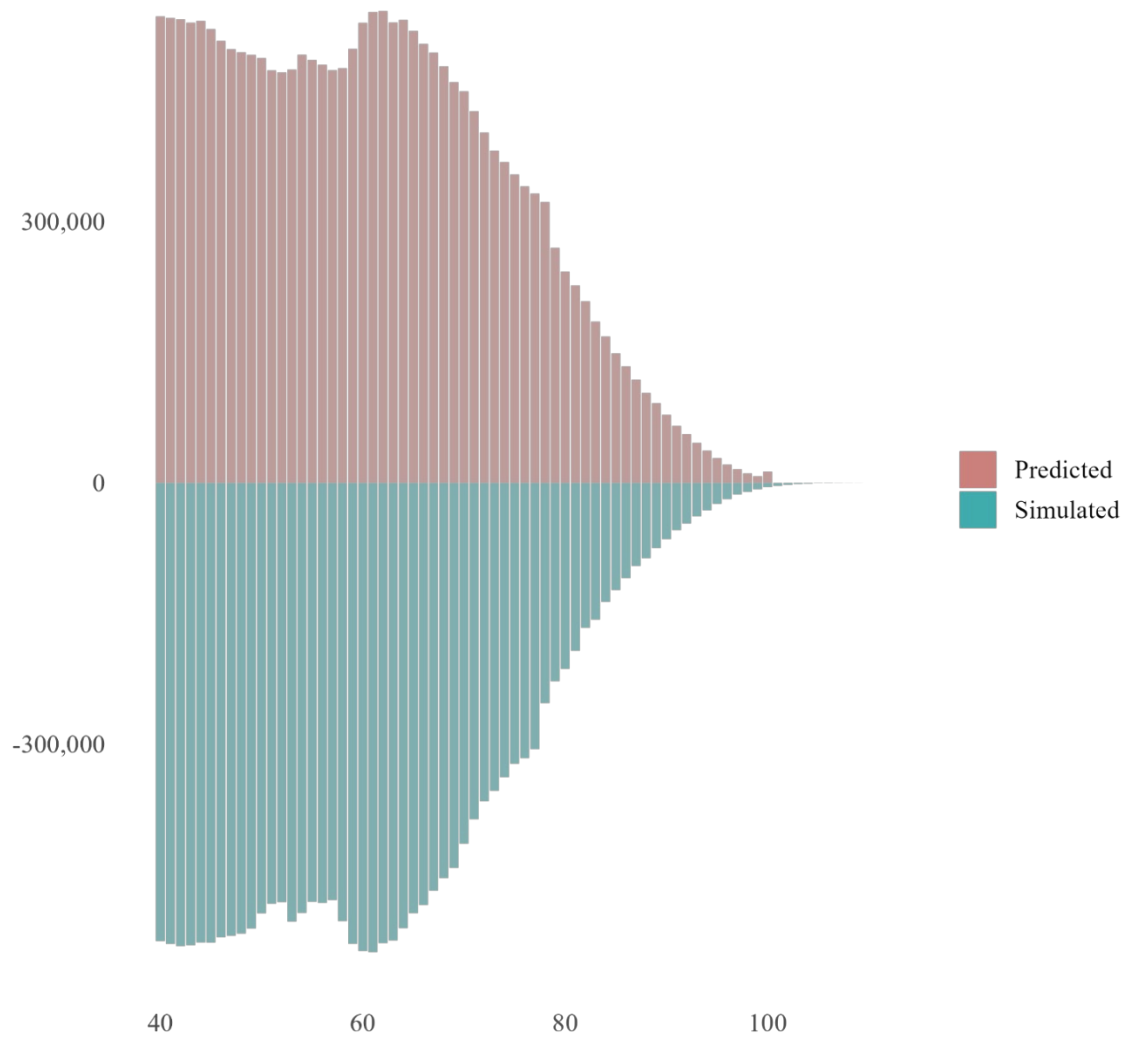


Figure 2: Comparison of EPIC-simulated and predicted population pyramid in 2025.

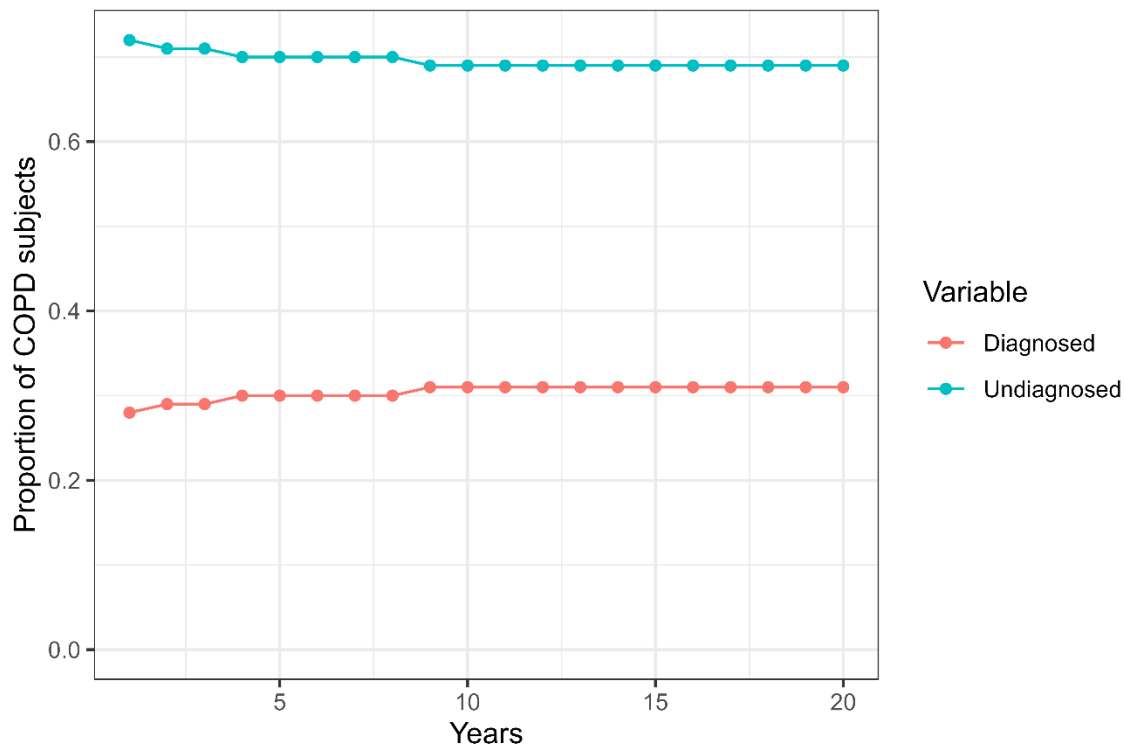


Figure 3: Proportion of COPD individuals diagnosed over a 20-year time horizon.

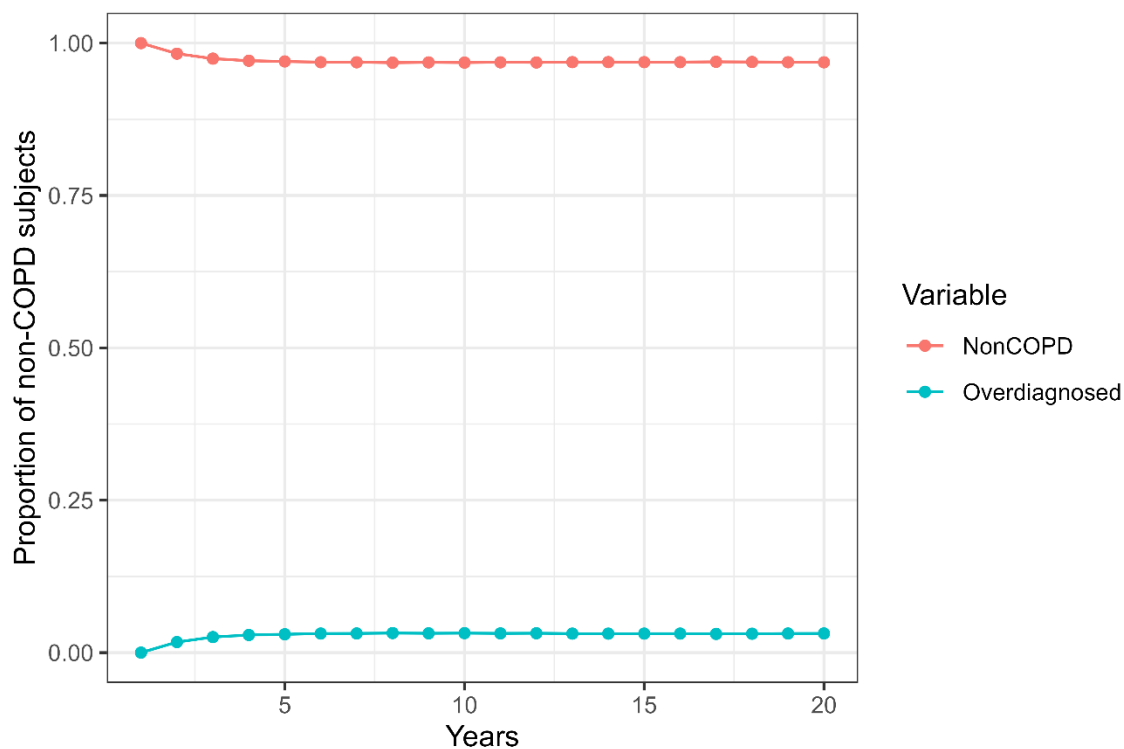


Figure 4: Proportion of non-COPD individuals overdiagnosed over a 20-year time horizon.

## Appendix 1B: Recalibrating the cost-effectiveness plane

The cost-effectiveness plane used by Johnson *et al.* (2021) was recalibrated at lower willingness-to-pay (WTP) thresholds. The preferred case detection strategy using the efficiency frontier approach with a WTP threshold of \$25,000/QALY gained was S3b (questionnaire-based screening for adults aged  $\geq 50$  years with a smoking history) (Figure 5).

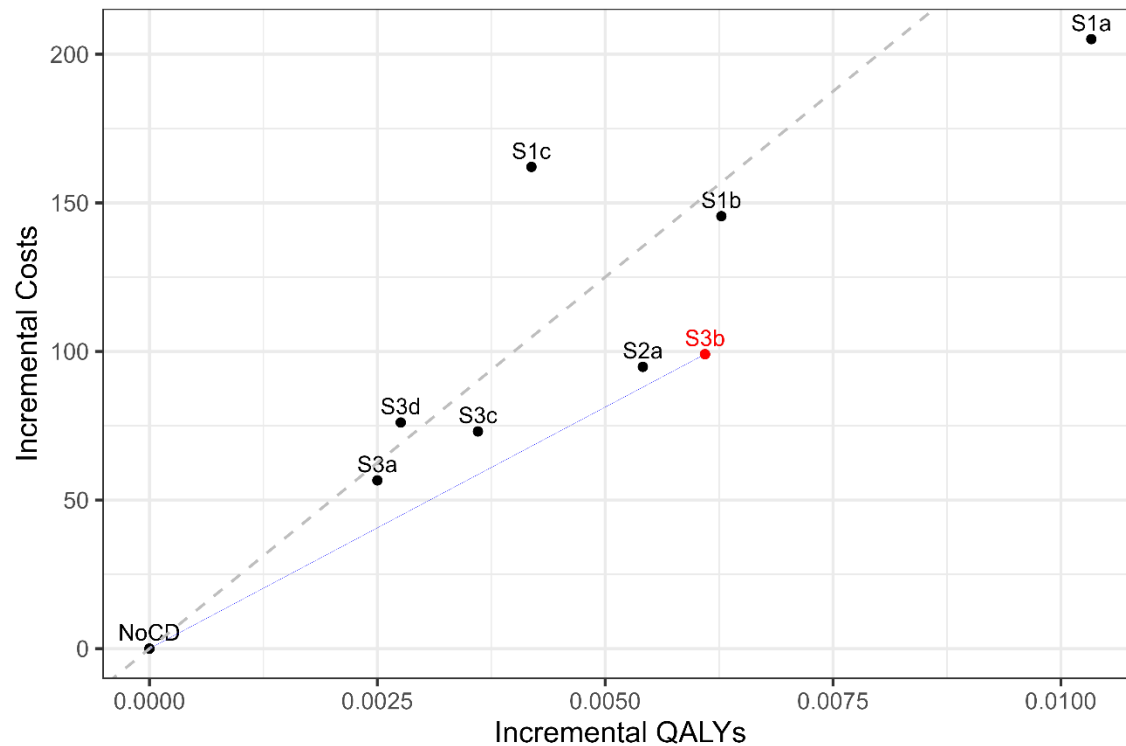


Figure 5: Cost-effectiveness plane for case detection scenarios. Solid blue line indicates the efficiency frontier, and the grey dashed line indicated the WTP threshold (\$25,000/QALY gained). The highest value scenario is highlighted in red.

## Appendix 1C: Budget impact results tables

Tables 1-8 show the extended annual budget impact results for each strategy compared to a baseline scenario of no case detection.

Table 1: Annual budget impact results for case detection strategy S1a.

Outcome	2021 (Baseline)	2022	2023	2024	2025	2026
<i>No case detection strategy costs</i>						
CD: time	0	0	0	0	0	0
CD: use cost	0	0	0	0	0	0
Treatment	393,530,276	417,513,737	438,863,110	460,607,046	481,266,209	501,851,770
Hospitalisation	857,500,298	886,643,782	915,325,378	951,343,357	994,360,219	1,038,253,318
Outpatient	1,382,501,810	1,427,522,685	1,475,284,754	1,529,463,255	1,587,334,011	1,646,461,799
Total	2,633,532,385	2,731,680,204	2,829,473,242	2,941,413,658	3,062,960,439	3,186,566,886
<i>Case detection strategy costs</i>						
CD: time	0	8,426,599	16,512,477	23,225,846	27,980,080	30,417,175
CD: use cost	0	23,182,793	45,379,385	63,882,768	76,851,041	83,544,168
Treatment	393,530,276	418,197,267	442,737,753	470,714,863	500,838,467	532,892,687
Hospitalisation	857,500,298	886,324,440	914,199,119	948,754,968	990,866,199	1,032,316,209
Outpatient	1,382,501,810	1,426,806,092	1,472,958,585	1,524,109,881	1,578,888,806	1,634,717,281
Total	2,633,532,385	2,762,937,191	2,891,787,318	3,030,688,325	3,175,424,593	3,313,887,519
<i>Budget impact</i>						
CD: time	0	-8,426,599	16,512,477	-23,225,846	-27,980,080	-30,417,175
CD: use cost	0	-23,182,793	-45,379,385	-63,882,768	-76,851,041	-83,544,168
Treatment	0	-683,530	-3,874,643	-10,107,817	-19,572,258	-31,040,917
Hospitalisation	0	319,343	1,126,259	2,588,389	3,494,020	5,937,109
Outpatient	0	716,593	2,326,169	5,353,374	8,445,205	11,744,518
Total	0	-31,256,986	-62,314,077	-89,274,668	-112,464,154	-127,320,633

CD: case detection.

Table 2: Annual budget impact results for case detection strategy S1b.

Outcome	2021 (Baseline)	2022	2023	2024	2025	2026
<i>No case detection strategy costs</i>						
CD: time	0	0	0	0	0	0
CD: use cost	0	0	0	0	0	0
Treatment	393,530,276	417,513,737	438,863,110	460,607,046	481,266,209	501,851,770
Hospitalisation	857,500,298	886,643,782	915,325,378	951,343,357	994,360,219	1,038,253,318
Outpatient	1,382,501,810	1,427,522,685	1,475,284,754	1,529,463,255	1,587,334,011	1,646,461,799
Total	2,633,532,385	2,731,680,204	2,829,473,242	2,941,413,658	3,062,960,439	3,186,566,886
<i>Case detection strategy costs</i>						
CD: time	0	8,426,599	16,512,477	23,225,846	27,980,080	30,417,175
CD: use cost	0	18,095,941	35,403,697	49,809,695	59,924,520	65,138,034
Treatment	393,530,276	417,502,295	439,839,584	464,000,396	488,865,354	514,550,406
Hospitalisation	857,500,298	886,488,161	915,155,450	949,922,059	992,470,688	1,035,052,965

Outpatient	1,382,501,810	1,427,128,994	1,473,885,031	1,526,189,614	1,582,014,503	1,639,472,537
Total	2,633,532,385	2,757,641,990	2,880,796,239	3,013,147,609	3,151,255,145	3,284,631,118
<b>Budget impact</b>						
CD: time	0	-8,426,599	-16,512,477	-23,225,846	-27,980,080	-30,417,175
CD: use cost	0	-18,095,941	-35,403,697	-49,809,695	-59,924,520	65,138,034
Treatment	0	11,442	-976,475	-3,393,350	-7,599,146	-12,698,637
Hospitalisation	0	155,621	169,929	1,421,298	1,889,531	3,200,353
Outpatient	0	393,691	1,399,723	3,273,642	5,319,508	6,989,261
Total	0	-25,961,786	-51,322,997	-71,733,952	-88,294,706	-98,064,232

CD: case detection.

Table 3: Annual budget impact results for case detection strategy S1c.

Outcome	2021 (Baseline)	2022	2023	2024	2025	2026
<b>No case detection strategy costs</b>						
CD: time	0	0	0	0	0	0
CD: use cost	0	0	0	0	0	0
Treatment	393,530,276	417,513,737	438,863,110	460,607,046	481,266,209	501,851,770
Hospitalisation	857,500,298	886,643,782	915,325,378	951,343,357	994,360,219	1,038,253,318
Outpatient	1,382,501,810	1,427,522,685	1,475,284,754	1,529,463,255	1,587,334,011	1,646,461,799
Total	2,633,532,385	2,731,680,204	2,829,473,242	2,941,413,658	3,062,960,439	3,186,566,886
<b>Case detection strategy costs</b>						
CD: time	0	8,426,599	16,512,477	23,225,846	27,980,080	30,417,175
CD: use cost	0	24,838,754	48,648,753	68,439,896	82,366,712	89,561,692
Treatment	393,530,276	417,277,873	438,904,708	461,889,458	485,073,969	508,838,130
Hospitalisation	857,500,298	886,545,719	915,165,446	950,042,531	992,523,607	1,035,330,430
Outpatient	1,382,501,810	1,427,235,127	1,474,200,864	1,526,918,210	1,583,028,815	1,641,116,604
Total	2,633,532,385	2,764,324,071	2,893,432,247	3,030,515,942	3,170,973,183	3,305,264,032
<b>Budget impact</b>						
CD: time	0	-8,426,599	-16,512,477	-23,225,846	-27,980,080	-30,417,175
CD: use cost	0	-24,838,754	-48,648,753	-68,439,896	-82,366,712	-89,561,692
Treatment	0	235,864	-41,599	-1,282,412	-3,807,760	-6,986,361
Hospitalisation	0	98,063	159,933	1,300,825	1,836,612	2,922,888
Outpatient	0	287,558	1,083,890	2,545,045	4,305,196	5,345,195
Total	0	-32,643,867	-63,959,006	-89,102,284	-108,012,744	-118,697,145

CD: case detection.

Table 4: Annual budget impact results for case detection strategy S2a.

Outcome	2021 (Baseline)	2022	2023	2024	2025	2026
<b>No case detection strategy costs</b>						
CD: time	0	0	0	0	0	0
CD: use cost	0	0	0	0	0	0
Treatment	393,530,276	417,513,737	438,863,110	460,607,046	481,266,209	501,851,770
Hospitalisation	857,500,298	886,643,782	915,325,378	951,343,357	994,360,219	1,038,253,318
Outpatient	1,382,501,810	1,427,522,685	1,475,284,754	1,529,463,255	1,587,334,011	1,646,461,799



Total	2,633,532,385	2,731,680,204	2,829,473,242	2,941,413,658	3,062,960,439	3,186,566,886
<i>Case detection strategy costs</i>						
CD: time	0	5,004,082	9,995,920	14,512,228	18,294,522	21,179,422
CD: use cost	0	11,288,986	22,462,791	32,590,260	41,111,291	47,541,278
Treatment	393,530,276	417,643,275	440,194,486	464,888,659	490,426,731	516,246,279
Hospitalisation	857,500,298	886,890,213	917,303,826	950,967,898	991,630,518	1,031,811,258
Outpatient	1,382,501,810	1,427,009,214	1,473,636,753	1,526,851,278	1,581,440,262	1,639,090,025
Total	2,633,532,385	2,747,835,770	2,863,593,776	2,989,810,322	3,122,903,323	3,255,868,263
<i>Budget impact</i>						
CD: time	0	-5,004,082	-9,995,920	-14,512,228	-18,294,522	-21,179,422
CD: use cost	0	-11,288,986	-22,462,791	-32,590,260	-41,111,291	-47,541,278
Treatment		-129,538	-1,331,377	-4,281,613	-9,160,522	-14,394,510
Hospitalisation	0	-246,431	-1,978,448	375,459	2,729,702	6,442,060
Outpatient	0	513,471	1,648,001	2,611,978	5,893,749	7,371,774
Total	0	-16,155,566	-34,120,535	-48,396,664	-59,942,884	-69,301,376

CD: case detection.

Table 5: Annual budget impact results for case detection strategy S3a.

Outcome	2021 (Baseline)	2022	2023	2024	2025	2026
<i>No case detection strategy costs</i>						
CD: time	0	0	0	0	0	0
CD: use cost	0	0	0	0	0	0
Treatment	393,530,276	417,513,737	438,863,110	460,607,046	481,266,209	501,851,770
Hospitalisation	857,500,298	886,643,782	915,325,378	951,343,357	994,360,219	1,038,253,318
Outpatient	1,382,501,810	1,427,522,685	1,475,284,754	1,529,463,255	1,587,334,011	1,646,461,799
Total	2,633,532,385	2,731,680,204	2,829,473,242	2,941,413,658	3,062,960,439	3,186,566,886
<i>Case detection strategy costs</i>						
CD: time	0	3,614,923	6,996,089	9,691,191	11,515,588	12,319,716
CD: use cost	0	7,321,358	14,133,386	19,504,765	23,177,778	24,826,494
Treatment	393,530,276	417,315,771	438,732,867	461,384,970	483,317,058	505,457,281
Hospitalisation	857,500,298	888,080,237	915,186,809	951,013,298	993,184,504	1,033,515,705
Outpatient	1,382,501,810	1,427,151,698	1,474,621,789	1,528,567,283	1,585,023,474	1,644,148,744
Total	2,633,532,385	2,743,483,986	2,849,670,940	2,970,161,507	3,096,218,403	3,220,267,939
<i>Budget impact</i>						
CD: time	0	-3,614,923	-6,996,089	-9,691,191	-11,515,588	-12,319,716
CD: use cost	0	-7,321,358	-14,133,386	-19,504,765	-23,177,778	-24,826,494
Treatment	0	197,966	130,243	-777,924	-2,050,849	-3,605,511
Hospitalisation	0	-1,436,454	138,570	330,059	1,175,715	4,737,614
Outpatient	0	370,987	662,965	895,972	2,310,537	2,313,055
Total	0	-11,803,782	-20,197,698	-28,747,849	-33,257,963	-33,701,053

CD: case detection.

Table 6: Annual budget impact results for case detection strategy S3b.

Outcome	2021 (Baseline)	2022	2023	2024	2025	2026
---------	--------------------	------	------	------	------	------

<i>No case detection strategy costs</i>						
CD: time	0	0	0	0	0	0
CD: use cost	0	0	0	0	0	0
Treatment	393,530,276	417,513,737	438,863,110	460,607,046	481,266,209	501,851,770
Hospitalisation	857,500,298	886,643,782	915,325,378	951,343,357	994,360,219	1,038,253,318
Outpatient	1,382,501,810	1,427,522,685	1,475,284,754	1,529,463,255	1,587,334,011	1,646,461,799
Total	2,633,532,385	2,731,680,204	2,829,473,242	2,941,413,658	3,062,960,439	3,186,566,886
<i>Case detection strategy costs</i>						
CD: time	0	3,614,923	6,996,089	9,691,191	11,515,588	12,319,716
CD: use cost	0	11,419,437	22,042,829	30,502,949	36,241,553	38,805,529
Treatment	393,530,276	417,904,014	441,044,569	466,551,891	492,458,299	519,274,253
Hospitalisation	857,500,298	887,932,717	915,133,889	950,001,828	992,166,827	1,031,847,452
Outpatient	1,382,501,810	1,426,894,720	1,473,704,146	1,526,774,157	1,582,156,778	1,639,691,744
Total	2,633,532,385	2,747,765,811	2,858,921,522	2,983,522,015	3,114,539,046	3,241,938,693
<i>Budget impact</i>						
CD: time	0	-3,614,923	-6,996,089	-9,691,191	-11,515,588	-12,319,716
CD: use cost	0	-11,419,437	-22,042,829	-30,502,949	-36,241,553	-38,805,529
Treatment	0	-354,498	-1,879,732	-5,565,440	-10,484,144	-17,249,349
Hospitalisation	0	2,086,309	-1,918,798	3,748,029	2,246,765	3,386,751
Outpatient	0	-219,296	1,065,053	1,551,379	4,970,980	5,143,954
Total	0	-13,636,897	-31,901,672	-40,800,360	-51,418,050	-60,300,220

CD: case detection.

Table 7: Annual budget impact results for case detection strategy S3c.

Outcome	2021 (Baseline)	2022	2023	2024	2025	2026
<i>No case detection strategy costs</i>						
CD: time	0	0	0	0	0	0
CD: use cost	0	0	0	0	0	0
Treatment	393,530,276	417,513,737	438,863,110	460,607,046	481,266,209	501,851,770
Hospitalisation	857,500,298	886,643,782	915,325,378	951,343,357	994,360,219	1,038,253,318
Outpatient	1,382,501,810	1,427,522,685	1,475,284,754	1,529,463,255	1,587,334,011	1,646,461,799
Total	2,633,532,385	2,731,680,204	2,829,473,242	2,941,413,658	3,062,960,439	3,186,566,886
<i>Case detection strategy costs</i>						
CD: time	0	3,614,923	6,996,089	9,691,191	11,515,588	12,319,716
CD: use cost	0	8,168,405	15,777,432	21,830,947	25,972,872	27,740,809
Treatment	393,530,276	417,595,501	439,815,630	463,797,758	487,644,177	511,947,716
Hospitalisation	857,500,298	888,032,675	915,174,395	950,639,141	992,516,680	1,032,900,277
Outpatient	1,382,501,810	1,427,012,736	1,474,176,971	1,527,669,771	1,583,628,648	1,641,959,473
Total	2,633,532,385	2,744,424,241	2,851,940,517	2,973,628,809	3,101,277,965	3,226,867,991
<i>Budget impact</i>						
CD: time	0	-3,614,923	-6,996,089	-9,691,191	-11,515,588	-12,319,716
CD: use cost	0	-8,168,405	-15,777,432	-21,830,947	-25,972,872	-27,740,809
Treatment	0	-81,764	-952,520	-3,190,712	-6,377,968	-10,095,946
Hospitalisation	0	-1,388,893	150,983	704,216	1,843,539	5,353,041
Outpatient	0	509,949	1,107,783	1,793,484	3,705,364	4,502,325
Total	0	-12,744,036	-22,467,275	-32,215,151	-38,317,526	-40,301,105

Appendix 1, as supplied by the authors. Appendix to: Mountain R, Kim D, Johnson KM. Budget impact analysis of adopting primary care-based case detection of chronic obstructive pulmonary disease in the Canadian general population. *CMAJ Open* 2023. doi: 10.9778/cmajo.20230023. Copyright © 2023 The Author(s) or their employer(s). To receive this resource in an accessible format, please contact us at cmajgroup@cmaj.ca.

CD: case detection.

Table 8: Annual budget impact results for case detection strategy S3d.

Outcome	2021 (Baseline)	2022	2023	2024	2025	2026
<i>No case detection strategy costs</i>						
CD: time	0	0	0	0	0	0
CD: use cost	0	0	0	0	0	0
Treatment	393,530,276	417,513,737	438,863,110	460,607,046	481,266,209	501,851,770
Hospitalisation	857,500,298	886,643,782	915,325,378	951,343,357	994,360,219	1,038,253,318
Outpatient	1,382,501,810	1,427,522,685	1,475,284,754	1,529,463,255	1,587,334,011	1,646,461,799
Total	2,633,532,385	2,731,680,204	2,829,473,242	2,941,413,658	3,062,960,439	3,186,566,886
<i>Case detection strategy costs</i>						
CD: time	0	3,614,923	6,996,089	9,691,191	11,515,588	12,319,716
CD: use cost	0	10,821,693	20,929,498	29,003,098	34,429,943	36,828,162
Treatment	393,530,276	417,463,330	439,317,841	462,665,119	485,642,400	508,979,062
Hospitalisation	857,500,298	888,060,245	915,246,260	950,806,652	992,681,448	1,033,176,370
Outpatient	1,382,501,810	1,427,097,525	1,474,411,581	1,528,047,035	1,584,247,905	1,642,978,516
Total	2,633,532,385	2,747,057,717	2,856,901,270	2,980,213,095	3,108,517,284	3,234,281,826
<i>Budget impact</i>						
CD: time	0	-3,614,923	-6,996,089	-9,691,191	-11,515,588	-12,319,716
CD: use cost	0	-10,821,693	-20,929,498	-29,003,098	-34,429,943	-36,828,162
Treatment	0	50,407	-454,732	-2,058,073	-4,376,191	-7,127,292
Hospitalisation	0	-1,416,463	79,118	536,705	1,678,771	5,076,948
Outpatient	0	425,160	873,173	1,416,220	3,086,106	3,483,283
Total	0	-15,377,513	-27,428,028	-38,799,437	-45,556,845	-47,714,940

CD: case detection.

## Appendix 1D: Overdiagnosis results

At baseline the prevalence of overdiagnosed COPD among non-COPD Canadians aged  $\geq 40$  years was 3.0%, which reflects the prevalence observed in the CanCOLD study (2).

Within EPIC, diagnosis and case detection are modelled as annual events and a patient cannot be overdiagnosed with COPD in the same year that they receive case detection.

Figure 6 shows prevalence of overdiagnosis among non-COPD patients over the time horizon. Overdiagnosis results are equivalent within eligibility criteria groups since each group selects the same cohort of patients for case detection. Compared to the baseline scenario (S0 – current practice) all case detection strategies result in a reduction in overdiagnosis prevalence. Strategies with eligibility criteria based on patients' smoking history (the S3 group) observes the smallest reduction since the S3 group has the strictest eligibility criteria thus is administering case detection to the smallest number of patients. The difference between the S1 (all patients) and S2 (symptomatic) group is minimal despite significant differences in the number of patients administered case detection (Table 3 of the main article). Symptoms are a significant risk factor for overdiagnosis so the S2 group is more targeted at patients who would typically be at greater risk of overdiagnosis.

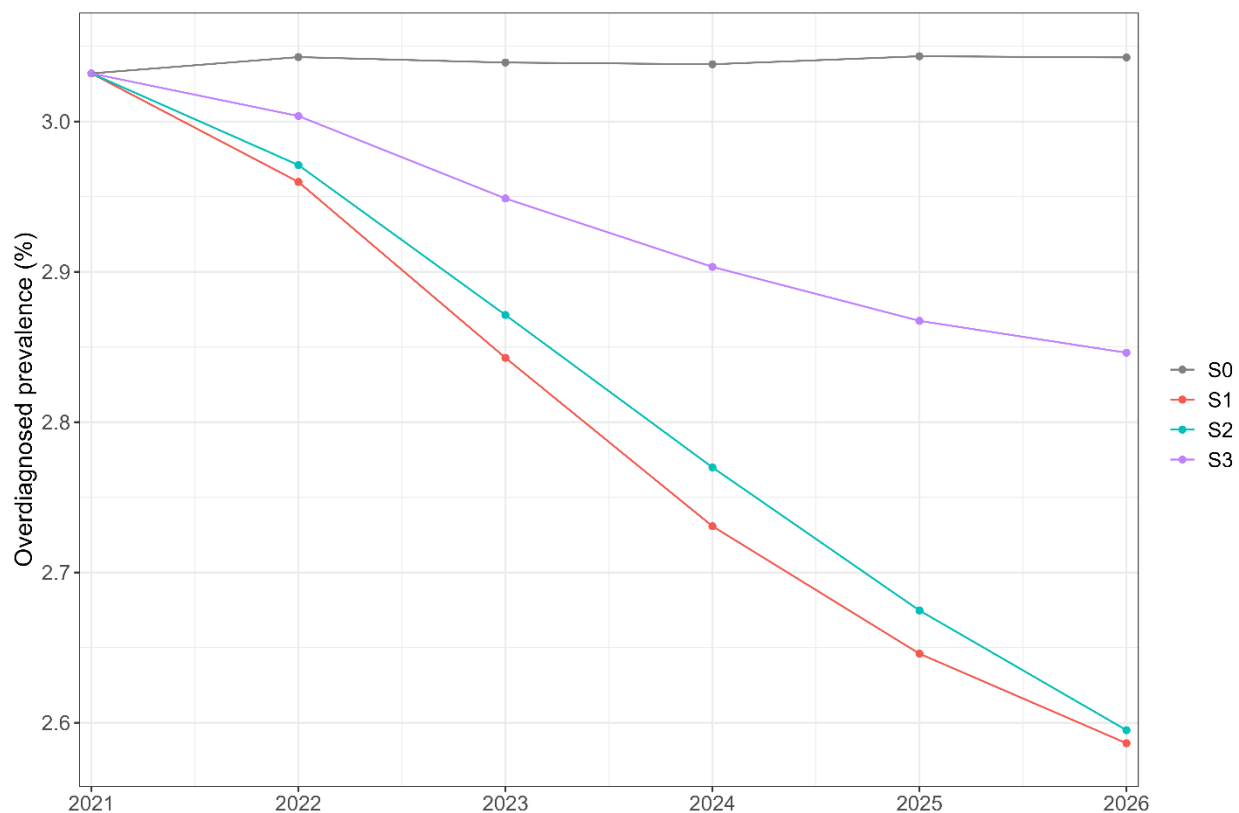
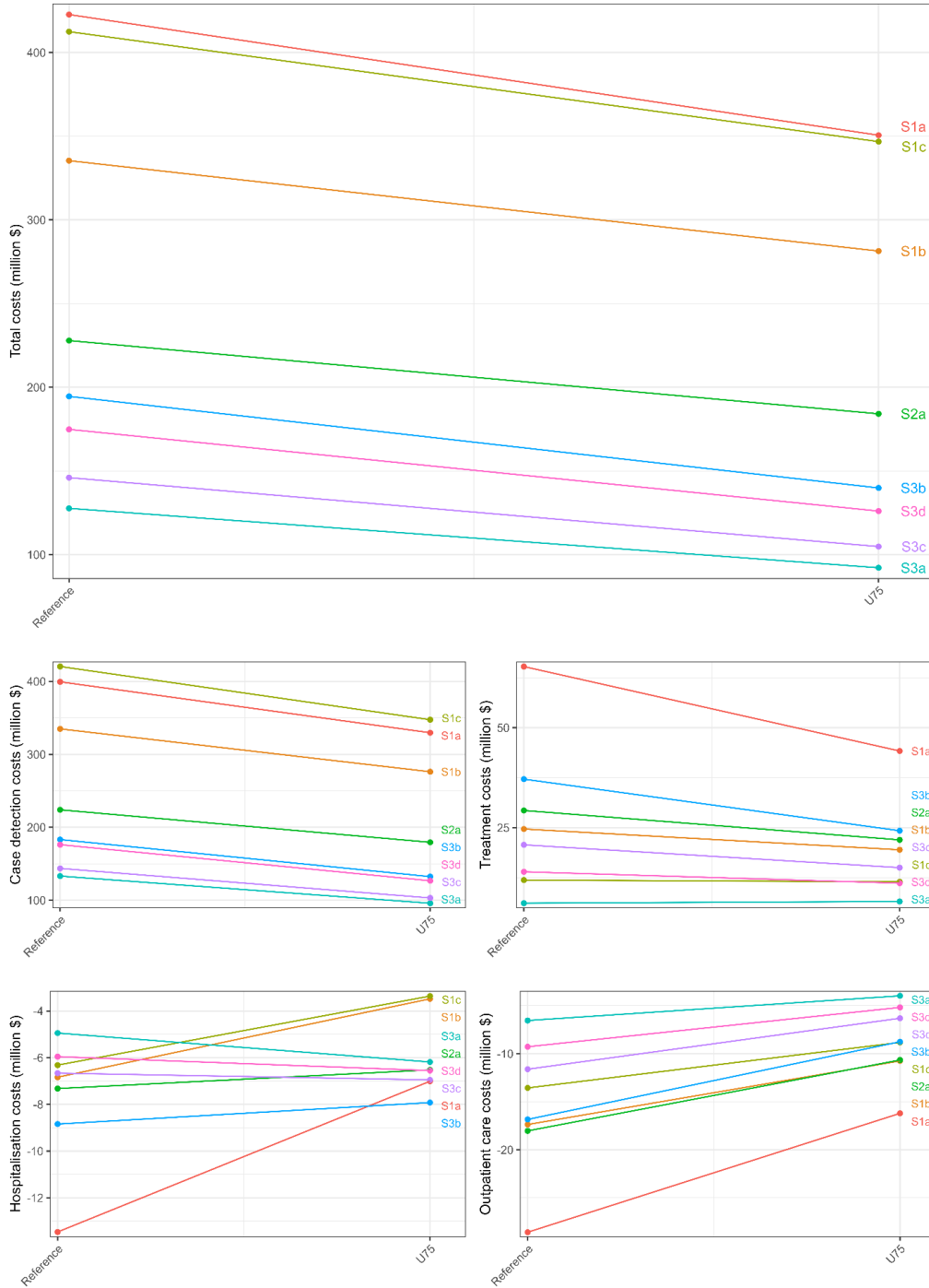


Figure 6: Prevalence of overdiagnosed COPD among non-COPD patients over the time horizon by eligibility criteria group. S0 - baseline (no case detection); S1 - all patients; S2 - symptomatic patients; S3 - patients with a smoking history.

## Appendix 1E: Additional sensitivity analysis results

Figure 7 shows sensitivity analysis results for a scenario with an upper age limit  $\leq 75$  years for considering patients for case detection. The overall budget expansion decreases on average by 22.5% with an upper age limit as fewer individuals would be administered case detection, and consequently, diagnosed. For S1a, the number of individuals administered case detection over the 5 years time horizon reduces by 1.5 million (from 8.9 million under to reference case to 7.4 million) and the budget expansion reduces by \$72 million (from \$423 million to \$351 million). By 2026, the diagnosed prevalence reaches 35.7% with an upper age limit compared to 37.8% under the reference case.



**Figure 7: Sensitivity analysis of total additional costs of case detection strategies compared to no case detection. Negative additional costs indicate cost savings. U75 – additional eligibility criteria  $\leq 75$  years. S1a CDQ  $\geq 17$  points for all patients; S1b flow meter (with bronchodilator) all patients; S1c CDQ  $\geq 17$  points + flow meter (with bronchodilator) all patients; S2a flow meter (without bronchodilator) among symptomatic patients; S3a CDQ  $\geq 19.5$  points among patients aged  $\geq 50$  years with a smoking history; S3b CDQ  $\geq 16.5$  points among patients aged  $\geq 50$  years with a smoking history; S3c flow meter (without bronchodilator) among patients aged  $\geq 50$  years with a smoking history, S3d CDQ  $\geq 17$  points + flow meter (with bronchodilator) among patients aged  $\geq 50$  years with a smoking history. Results based on a single run of EPIC per scenario.**

## References

1. Sadatsafavi M, Ghanbarian S, Adibi A, Johnson K, FitzGerald JM, Flanagan W, et al. Development and Validation of the Evaluation Platform in COPD (EPIC): A Population-Based Outcomes Model of COPD for Canada. *Medical Decision Making*. 2019 Feb; 39(2): 152-167.
2. Johnson KM, Sadatsafavi M, Adibi A, Lynd L, Harrison M, Tavakoli H, et al. Cost Effectiveness of Case Detection Strategies for the Early Detection of COPD. *Applied Health Economics and Health Policy*. 2021 Mar; 19(2): 203-215.
3. Statistics Canada. Population Projections for Canada, Provinces and Territories. [Online]. [cited 2022 December 1. Available from: <https://www150.statcan.gc.ca/n1/en/catalogue/91-520-X>.
4. Bourbeau J, Tan WC, Benedetti A, Aaron SD, Chapman KR, Coxson HO, et al. Canadian Cohort Obstructive Lung Disease (CanCOLD): Fulfilling the Need for Longitudinal Observational Studies in COPD. *COPD: Journal of Chronic Obstructive Pulmonary Disease*. 2014 Apr; 11(2): 125-132.
5. Labonté LE, Tan WC, Li PZ, Mancino P, Aaron SD, Benedetti A, et al. Undiagnosed Chronic Obstructive Pulmonary Disease Contributes to the Burden of Health Care Use. Data from the CanCOLD Study. *American Journal of Respiratory and Critical Care Medicine*. 2016 Aug; 194(3): 285-298.
6. Gershon AS, Thiruchelvam D, Chapman KR, Aaron SD, Stanbrook MB, Bourbeau J, et al. Health Services Burden of Undiagnosed and Overdiagnosed COPD. *Chest*. 2018 Jun; 153(6): 1336-1346.