Research

Budget impact analysis of adopting primary care–based case detection of chronic obstructive pulmonary disease in the Canadian general population

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Abstract

Background: An estimated 70% of Canadians with chronic obstructive pulmonary disease (COPD) have not received a diagnosis, creating a barrier to early intervention, and there is growing interest in the value of primary care–based opportunistic case detection for COPD. We sought to build on a previous cost-effectiveness analysis by evaluating the budget impact of adopting COPD case detection in the Canadian general population.

Methods: We used a validated discrete-event microsimulation model of COPD in the Canadian general population aged 40 years and older to assess the costs of implementing 8 primary care–based case detection strategies over 5 years (2022–2026) from the health care payer perspective. Strategies varied in eligibility criteria (based on age, symptoms or smoking history) and testing technology (COPD Diagnostic Questionnaire [CDQ] or screening spirometry). Costs were determined from Canadian studies and converted to 2021 Canadian dollars. Key parameters were varied in one-way sensitivity analysis.

Results: All strategies resulted in higher total costs compared with routine diagnosis. The most cost-effective scenario (the CDQ for all patients) had an associated total budget expansion of $423 million, with administering case detection and subsequent diagnostic spirometry accounting for 86% of costs. This strategy increased the proportion of individuals diagnosed with COPD from 30.4% to 37.8%, and resulted in 4.6 million referrals to diagnostic spirometry. Results were most sensitive to uptake in primary care.

Interpretation: Adopting a national COPD case detection program would be an effective method for increasing diagnosis of COPD, dependent on successful uptake. However, it will require prioritisation by budget holders and substantial additional investment to improve access to diagnostic spirometry.

hronic obstructive pulmonary disease (COPD) affects 2.6 million Canadians and is the third leading cause of death worldwide.[1,2] Quality of life for patients with COPD can be considerably impaired by the burden of symptoms and subsequent exacerbations, affecting their ability to partake in daily activities.[3] Diagnosis is critical for clinical intervention to reduce symptoms and the risk of exacerbations through optimal preventive and therapeutic management, particularly smoking cessation.[4] Despite major social and clinical implications, an estimated 70% of Canadians with COPD have not received a diagnosis and experience worse long-term health outcomes through late recognition of their condition.[5,6] Although COPD is recognized as an ambulatory-sensitive condition, meaning hospital admissions can be avoided through optimal outpatient management, one-third of patients are initially diagnosed in hospital after an exacerbation-related admission.[7,8] Guidelines recommend against screening of asymptomatic adults owing to lack of evidence that diagnosis before symptom development improves patient outcomes. However, "asymptomatic"

is an ambiguous concept; 50% of adults with airflow obstruction fail to report symptoms or mask symptoms by limiting physical activity.[9,10] Given the substantial burden associated with undiagnosed COPD, there is a need for further research into alternative earlier detection strategies.[11–13] Emerging evidence from clinical trials and modelling studies demonstrates that targeted, opportunistic case detection in primary care improves long-term patient outcomes and is likely to be cost effective.[14–16] A recent cost-effectiveness analysis by Johnson and colleagues[16] evaluated primary care–based COPD case detection strategies in the general Canadian population. At a willingness-to-pay (WTP) threshold

of $50 000 per quality-adjusted life-year (QALY) gained, case detection with symptom- and risk factor–based questionnaires or screening spirometry was cost effective. The highest-value strategy was regularly administering the COPD Diagnostic Questionnaire (CDQ) at 3-year intervals to all patients aged 40 years and older during routine primary care interactions.[16]

However, given the high prevalence of undiagnosed COPD, investment in a national COPD case detection program would require considerable allocation of health care resources. In a time of intense pressure on health care budgets, we must consider the affordability of an intervention as well as its value. The aim of our study was to build on a previous cost-effectiveness analysis by evaluating the budget impact of adopting primary care–based COPD case detection in the general Canadian population.[16] We assessed total medical costs from the health care payer perspective of implementing 8 case detection strategies that vary in their eligibility criteria and testing technology over a 5-year time horizon between 2022 and 2026.

Methods

This study was designed in accordance with the The Professional Society for Health Economics and Outcomes Research (formerly the International Society for Pharmacoeconomics and Outcomes Research) best practice guidelines for budget impact analysis.[17]

Setting
Our analysis is from the perspective of the Canadian health care system and considers a 5-year study period from 2022 to 2026. The total population of Canada was 38.9 million in 2022, with a median age of 41 years, based on Statistics Canada projections.[18] The target population for case detection intervention was the general Canadian population aged 40 years and older, of size 19.8 million in 2022.[18] The eligible population was the subset of the target population that was eligible for case detection, which varied by strategy. We report the budget impact for the target population for comparability between strategies with different eligibility criteria. Our analysis was implemented in an open population, meaning individuals enter and exit the target population throughout the time horizon.

Analytic framework
We used the Evaluation Platform in COPD (EPIC), a previously validated deterministic discrete-event microsimulation model of COPD in the general Canadian population aged 40 years and older. EPIC simulates the development and progression of COPD across the entire disease pathway, including demographic characteristics of the general Canadian population, smoking prevalence, COPD occurrence, symptoms, primary care visits, COPD diagnosis, lung function decline, exacerbations, COPD-related and background mortality, medical costs and QALYs over a lifetime horizon.[19] EPIC uses data from the Canadian Cohort of Obstructive Lung Disease (CanCOLD) study, a national

prospective cohort study of patients with COPD and at risk of COPD, to model community diagnosis, primary care utilization and respiratory symptoms.[20] Smoking status is based on the Population Health Model, a validated microsimulation model developed by Statistics Canada.[21] Each component of EPIC has passed rigorous tests of internal and external validity[16,19] (Appendix 1A, available at www.cmajopen.ca/content/11/6/E1048/suppl/DC1) and EPIC is an open-source R package.[22]

This analysis simulated within EPIC the implementation of COPD case detection administered during routine primary care visits over a 5-year time horizon (2022–2026).

Case detection
We evaluated 8 case detection strategies used in the cost-effectiveness analysis by Johnson and colleagues,[16] all of which were found to be cost effective at a WTP of $50 000/QALY. We did not consider repeat testing of the same individual at specified intervals owing to the short time horizon and to show the costs of a single implementation of each strategy. Strategies are grouped according to their eligibility criteria for selecting patients to receive case detection, either all patients (S1), symptomatic patients (any 1 of cough, phlegm, wheeze or dyspnea) (S2), or patients aged 50 years and older with a smoking history (S3). The testing technologies considered are the CDQ[23] and the hand-held flow metre,[24] which performs screening spirometry based on the ratio of forced expiratory volume in 1 second to forced expiratory volume in 6 seconds less than 0.7. All scenarios were compared with a baseline scenario of no case detection. The case detection strategies evaluated are summarized in Table 1.

Although we replicated all 8 strategies reported by Johnson and colleagues,[16] our reporting focuses on S1a (CDQ ≥ 17 points for all patients), the highest-value strategy identified at a WTP threshold of $50 000/QALY gained. However, guidelines suggest that interventions with a large budgetary impact should be subject to lower cost-effectiveness thresholds.[25] We reanalyzed the cost-effectiveness plane in Johnson and colleagues[16] (Appendix 1B) and found that the WTP threshold must be reduced to $25 000/QALY for S1a to no longer be the preferred strategy, at which point S3b (CDQ ≥ 16.5 points for patients aged ≥ 50 yr with a smoking history) becomes most cost effective. Therefore, for comparison, we also discuss results for S3b.

To be eligible for case detection, individuals must fulfill the eligibility criteria and have visited primary care in the previous year. Figure 1 provides a schematic for administration of case detection programs. Patients testing positive at case detection were referred to outpatient diagnostic spirometry, which we assumed to have 100% accuracy. We modelled gradual market penetration by assuming a linear uptake from 5% in 2022 to 25% in 2026, based on participation in lung and colon cancer screening programs.[26,27] Throughout the simulation, patients could also be diagnosed with COPD at primary care visits without the use of case detection or after an exacerbation-related hospital admission (Appendix 1A).

Table 1: Summary of case detection strategies evaluated			
Testing technology	Eligibility criteria	Sensitivity, %*	Specificity, %*
(S1) All patients			
S1a: CDQ ≥ 17 points	None	91.0	49.0
S1b: Flow metre (with bronchodilator)		80.0	94.0
S1c: CDQ ≥ 17 points + flow metre (with bronchodilator)		72.0	97.0
(S2) Symptomatic patients			
S2a: Flow metre (without bronchodilator)	≥ 1 respiratory symptom†	81.5	88.9
(S3) Smoking history			
S3a: CDQ ≥ 19.5 points	Past or current smoker Age ≥ 50 yr	64.5	65.2
S3b: CDQ ≥ 16.5 points		87.5	38.8
S3c: Flow metre (without bronchodilator)		79.9	84.4
S3d: CDQ ≥ 17 points + flow metre (with bronchodilator)		74.4	97.0

Note: CDQ = COPD diagnostic questionnaire, COPD = chronic obstructive pulmonary disease.
*Sensitivity and specificity values are derived from the literature and further details have been provided previously.[16] Sensitivity and specificity values relate to the outcome of the case detection test only; patients testing positive are then referred for diagnostic spirometry, which we assume to have 100% accuracy.
†Respiratory symptoms defined as the presence of chronic cough in the absence of a cold, any wheeze, phlegm in the absence of a cold, or dyspnea, measured using the Medical Research Council dyspnea scale with a score of 2–5 indicating the presence of dyspnea, in the past year.

Inputs

Table 2 summarizes the costs and model parameter input values used for analysis. We include direct COPD health care costs only. Costs were converted to 2021 Canadian dollars using the health care component of the Consumer Price Index[41] and were not discounted over the time horizon.[17]

Administering case detection was costed at 34% of a 15-minute routine primary care visit.[42,43] The CDQ is assigned only the time-related cost whereas flow metre strategies incur the additional cost of screening spirometry. Outpatient diagnosis includes the cost of diagnostic spirometry plus a primary care visit to interpret the results. Unit costs of utilization were determined from the British Columbia fee schedule.[28]

Within EPIC, inhaled therapies are assigned to individuals according to the Global Initiative for Chronic Obstructive Pulmonary Disease (GOLD) ABCD (A: low risk of exacerbation, fewer symptoms; B: low risk of exacerbation, more symptoms; C: high risk of exacerbation, fewer symptoms; and D: high risk of exacerbation, more symptoms) criteria following diagnosis or an exacerbation.[44] Average annual costs of treatment with inhaled therapies were determined from medication dispensation records in BC health administrative data.[29] Three months of nicotine replacement therapy (NRT) was administered to all newly diagnosed patients who were current smokers. The associated effect of treatment on health outcomes is summarized in Table 2. Adherence to both treatments was set at 70%. We assume 100% public drug coverage since all provinces have full coverage for adults aged 65 years and older, which will account for most COPD patients.[45]

The medical costs of exacerbations and background medical costs (outside of exacerbations and treatment) were determined from published Canadian studies and applied by exacerbation severity and GOLD grade.[36–39]

Analysis

Budget impact was calculated for each strategy and year as the difference in total costs from the baseline scenario, where negative budget impact indicates additional health care resources are required (budget expansion). We also evaluated cost subcategories of case detection, treatment (inhaled therapies and NRT) and exacerbation-related hospital admissions. In addition, we evaluated the performance of each strategy by reporting the size of the eligible population, number of case detections administered, number of referrals to outpatient diagnostic spirometry and number of additional true COPD diagnoses.

We conducted one-way sensitivity analysis to assess the impact of model assumptions. We evaluated low case detection uptake (2%–10% range; 2%/yr increase) and high uptake (8%–40% range; 8%/yr increase) scenarios. We ran separate analyses for reduced adherence to inhaled therapies of 0.5 and 0.3, following previous population assessments, and removing the administration of NRT following diagnosis since guidelines recommend smoking cessation for all current smokers irrespective of COPD diagnosis.[44,46] Further analysis was conducted with an age limit of 75 years and younger for case detection.

Ethics approval

Ethics approval was not required as this study did not involve analysis of human participants.
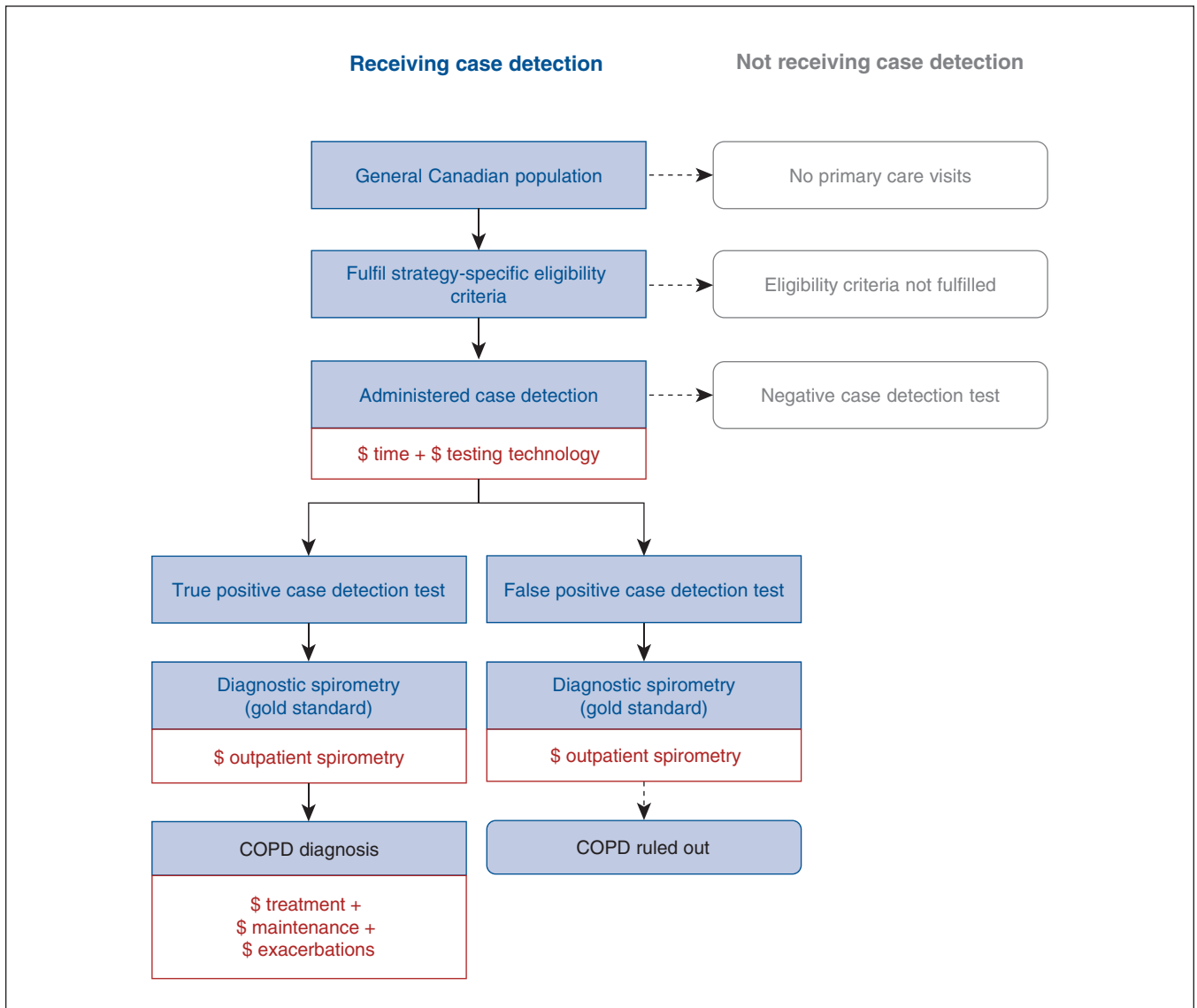
Figure 1: Schematic for administration of case detection programs. Individuals receiving case detection are shown in blue, and those not receiving case detection are shown in grey. Costs associated with case detection, diagnosis and treatment are included in red.

Results

The starting population size was 19.8 million for adults aged 40 years and older. Over the time horizon, 2.3 million individuals entered the model, and 940 000 left owing to death or emigration. At baseline, the COPD prevalence among Canadians aged 40 years and older was 11.9%, and 30.4% of individuals with COPD had received a diagnosis. These are similar to the COPD prevalence (11.2%) and proportion diagnosed (29.7%) observed in the CanCOLD study[5,47] (Appendix 1A).

The most inclusive strategies (S1: all patients aged ≥ 40 yr) resulted in 40.4% of the target population administered case detection after 5 years, compared with 16.7% under the least inclusive strategies (S3: patients ≥ 50 yr with a smoking history) (Table 3). In S1a (CDQ ≥ 17 points for all patients), an

additional 145 700 individuals with COPD received a diagnosis after 5 years compared with routine diagnosis in the no-case-detection scenario, which increased the proportion of individuals diagnosed with COPD to 37.8% (from 30.4%) by 2026. The diagnosed proportion increased to 34.1% under S3b (CDQ ≥ 16.5 points for patients ≥ 50 yr with a smoking history). However, S1a also resulted in 4.6 million referrals to diagnostic spirometry, 96% of which were false positives.

All strategies resulted in higher total costs compared with no case detection (Table 4). The greatest budget expansion was $423 million for S1a, with 86% of costs attributed to administering case detection and subsequent diagnostic spirometry. The corresponding results for S3b were $195 million and 83%. The costs of case detection began to plateau by the end of the time horizon as the proportion of eligible patients not already tested was depleted, whereas treatment

Table 2: Costs and parameter input values relevant to evaluation of case detection*		
Item	Value	References
Global parameters		
Time horizon	5 yr	
Population size	19.8 million	Statistics Canada[18]
Case detection initial uptake	0.05	Goffin et al.[26]
Annual increase in case detection uptake	0.05	
Discount for costs	0	Sullivan et al.[17]
Case detection costs, $		
Time-related cost for administration	11.91	BC Ministry of Health[28]
Flow metre with bronchodilator	18.90	
Flow metre without bronchodilator	12.77	
Outpatient diagnosis	62.19	
Treatment		
Costs (annual per patient),† $		
SABA	55.17	Tavakoli et al.[29]
LAMA	366.55	
LAMA/LABA	670.44	
ICS/LAMA/LABA	1185.23	
NRT	382.63	Mullen et al.[30]
Rate reduction for exacerbations		
SABA	0	
LAMA	0.22	Zhou et al.[31]
LAMA/LABA	0.23	Calverley et al.[32]
ICS/LAMA/LABA	0.34	Ferguson et al.[33]
NRT odds ratio for successful smoking cessation	1.38	Wu and et al.[34,35]
Medication adherence‡	0.7	
Exacerbation costs,§ $		
Mild	31.68	Mittman et al.[36] and Canadian Institute for Health Information[37]
Moderate	793.08	
Severe	10 063.13	
Very severe	22 033.60	
Maintenance costs (annual per patient),¶ $		
GOLD 1	147.48	Chapman et al.[38] and Spencer et al.[39]
GOLD 2	360.49	
GOLD 3	943.83	
GOLD 4	1286.84	

Note: CDQ = COPD Diagnosis Questionnaire, GOLD = Global Initiative for Chronic Obstructive Lung Disease, ICS = inhaled corticosteroids, LABA = long-acting β-agonist, LAMA = long-acting muscarinic antagonist, NRT = nicotine replacement therapy, SABA = short-acting β-agonists.
*General EPIC model parameters have been reported previously.[16,19] All costs are in 2021 Canadian dollars.
†Annual per-patient treatment costs are weighted by adherence (70% in the base case analysis).
‡Medication adherence of 70% means that out of 100 patient-years in which a patient was eligible for a medication, they only took the medication (and therefore received the benefit) in 70 patient-years.
§Mild exacerbations are defined as an intensification of symptoms that does not require an encounter with the health care system and so are only assigned the cost of increased medication; moderate exacerbations are those in which the patient visits a physician or emergency department but is not hospitalized; severe exacerbations are assumed to result in a hospital admission, and very severe exacerbations in admission to the intensive care unit.
¶Maintenance costs are those that accrue outside of episodes of exacerbations and include physician visits (generalist and specialists), rehabilitation programs, laboratory tests and devices, and oxygen therapy. Treatment costs (that is, maintenance treatment and not exacerbation-related treatment) have been deducted from maintenance costs to avoid double counting.[40]

Table 3: Five-year (2022–2026) cumulative results on scope and performance of case detection strategies

Variable	Eligible* (% of target population)	Administered case detection (% of target population)	Referred for outpatient spirometry		Additional diagnoses† (% target population)
			True positives (% of tested)	False positives (% of tested)	
(S1) All patients					
S1a: CDQ ≥ 17	20 468 000 (92.4)	8 947 300 (40.4)	175 400 (2.0)	4 468 000 (49.9)	145 700 (0.66)
S1b: Flow metre			85 000 (0.9)	772 100 (8.6)	67 700 (0.31)
S1c: CDQ ≥ 17 + flow metre			58 100 (0.6)	412 900 (4.6)	44 600 (0.20)
(S2) Symptomatic patients					
S2a: Flow metre	18 760 100 (84.7)	5 792 300 (26.2)	87 000 (1.5)	1 161 600 (20.1)	69 800 (0.32)
(S3) Smoking history					
S3a: CDQ ≥ 19.5	8 486 300 (38.3)	3 705 900 (16.7)	28 000 (0.8)	1 382 600 (37.3)	22 000 (0.10)
S3b: CDQ ≥ 16.5			87 000 (2.3)	2 117 800 (57.1)	76 300 (0.34)
S3c: Flow metre			55 100 (1.5)	748 900 (20.2)	47 000 (0.21)
S3d: CDQ ≥ 17 + flow metre			42 400 (1.1)	184 600 (5.0)	35 300 (0.16)

Note: CDQ = COPD Diagnostic Questionnaire, COPD = chronic obstructive pulmonary disease.
Results based on a single run of EPIC per scenario.
*Eligible defined as meeting the eligibility criteria and having visited primary care within the same year over the time horizon.
†Additional diagnoses compared with routine diagnosis under the baseline scenario of no case detection, after 5 years.

costs continued to increase as more patients received a diagnosis (Figure 2). Minor cost savings were observed from exacerbation-related admissions and outpatient care from fewer mild and moderate exacerbations, respectively saving $6 million per year and $12 million per year under S1a by 2026.

Extended annual budget impact results for each strategy are presented in Appendix 1C, and the impact of case detection on overdiagnosis of COPD is considered in Appendix 1D.

Sensitivity analyses showed minimal change in the ranking of strategies across analyses (Figure 3). Total budget impact decreased by a maximum of 4.5% when NRT was removed or medication adherence was decreased since case detection administration, which comprises the majority of costs, was unaffected. Results were most affected by uptake, with higher uptake rates (8%–40% range; 8%/yr) resulting in greater budget expansion ($598 million under S1a) but also a greater proportion of patients who received a COPD diagnosis (40.1% by 2026 under S1a) compared with the reference analysis. Sensitivty analysis results for upper age limit are presented in Appendix 1E.

Interpretation

We used a validated whole disease microsimulation model to evaluate the budget impact to the Canadian health care system of adopting primary care–based early detection strategies for COPD. We have created a Web app that allows readers to modify cost and uptake inputs and examine their impact on results (https://resplab.shinyapps.io/bia-copd-mountain-2023/). Questionnaire-based testing for all patients aged 40 years and older during routine primary care visits, though most effective at increasing the diagnosed prevalence, would have a large bud-

getary impact of $423 million over 5 years, with budget expansion largely attributed to case detection in primary care and subsequent outpatient diagnosis. Total health care spending in Canada was estimated at $331 billion in 2022, representing 12.2% of the country's gross domestic product.[48] Implementing a country-wide COPD case detection program would require considerable additional investment of health care resources, accounting for an estimated 0.04% of the health care budget per year by 2026. If the budget impact of a more inclusive strategy is deemed too high, then we must accept a lower threshold for cost effectiveness. At a reduced WTP, the CDQ at a low threshold remains the preferred testing technology but paired with stricter eligibility criteria (age ≥ 50 yr with a smoking history), with a budget impact of $195 million.

This budget-impact analysis of COPD case detection strategies contributes an important affordability and feasibility assessment. Our analysis is monetary-focused and captures only benefits that result in cost savings. Therefore, it is important to interpret the results in the context of the preceding and complimentary cost-effectiveness analysis by Johnson and colleagues,[16] which established the value of the strategies considered in terms of QALYs gained by patients diagnosed earlier through case detection. Other existing literature has evaluated the performance of COPD case detection in improving long-term patient outcomes.[14–16] We provide additional evidence showing that case detection can be a successful method for reducing the prevalence of undiagnosed COPD when applied to a large population, dependent on strategy selected and rate of uptake. Strategies targeting a more limited population increase the proportion of diagnosed patients by a smaller proportion, but the total budgetary impact is smaller.

Table 4: Total budget impact (no case detection–case detection) results								
Outcome	S1a	S1b	S1c	S2a	S3a	S3b	S3c	S3d
No case detection strategy costs (million $)								
Case detection: physician time*				0				
Case detection: use cost*				0				
Treatment				2300				
Hospital admission				4786				
Outpatient†				7666				
Total				14 752				
Case detection strategy costs (million $)								
Case detection: physician time*	107	107	107	69	44	44	44	44
Case detection: use cost*	293	228	314	155	89	139	99	132
Treatment	2365	2325	2312	2329	2306	2337	2321	2314
Hospital admission	4772	4779	4780	4779	4781	4777	4779	4780
Outpatient†	7637	7649	7652	7648	7660	7649	7654	7657
Total	15 175	15 087	15 165	14 980	14 880	14 947	14 898	14 927
Budget impact (million $)‡								
Case detection: physician time*	−107	−107	−107	−69	−44	−44	−44	−44
Case detection: use cost*	−293	−228	−314	−155	−89	−139	−99	−132
Treatment	−65	−25	−12	−29	−6	−37	−21	−14
Hospitalization	13	7	6	7	5	9	7	6
Outpatient†	29	17	14	18	7	17	12	9
Total	−423	−335	−412	−228	−128	−195	−146	−175

Note: S1a = CDQ ≥ 17 points for all patients, S1b = flow metre (with bronchodilator) all patients, S1c = CDQ ≥ 17 points + flow metre (with bronchodilator) all patients, S2a = flow metre (without bronchodilator) among symptomatic patients, S3a = CDQ ≥ 19.5 points among patients aged ≥ 50 yr with a smoking history, S3b = CDQ ≥ 16.5 points among patients aged ≥ 50 yr with a smoking history, S3c = flow metre (without bronchodilator) among patients aged ≥ 50 years with a smoking history, S3d = CDQ ≥ 17 points + flow metre (with bronchodilator) among patients aged ≥ 50 yr with a smoking history.
Results based on a single run of EPIC per scenario.
*Case detection costs have been split by time (time-related cost of physician implementing case detection) and use cost (cost of flow meter technology and outpatient spirometry diagnosis).
†Outpatient care are the remaining costs not included in case detection, treatment or hospital admission and includes COPD maintenance costs, routine diagnosis, and costs associated with mild and moderate exacerbations which are assumed not to result in hospital admission.
‡Negative budget impact indicates budget expansion.

Our results highlight the need for increased diagnostic spirometry capacity, which may be the greatest barrier to implementing COPD case detection. A COPD diagnosis can be confirmed only by use of spirometry, yet there is massive underutilization of this diagnostic test globally.[49,50] In Canada, estimates for the proportion of patients with a community diagnosis of COPD who have never received spirometry range from 30% to 42%.[50,51] A principal reason for this is lack of equipment and trained personnel for spirometry in primary care, where 80% of patients with COPD in Canada are managed.[38] Primary care practitioners often refer patients to specialized pulmonary function laboratories, which can have long waiting lists and create further access barriers for rural and remote parts of Canada.[52,53] Most strategies considered in this analysis would require at least 1 million diagnostic spirometry tests over 5 years, which we assume to be referred to outpatient services. Future research and discussions must consider solutions for upskilling primary care to perform diagnostic spirometry if COPD case-finding strategies in the entire Canadian population are to be feasible.

Limitations

This study has several limitations. Our analysis based uptake on general population participation in lung and colon cancer screening in Canada.[26,27] Spirometry is a comparatively less invasive procedure so may have higher uptake, but given major issues with spirometry access, we do not exceed 40% per year as the upper limit in sensitivity analyses.[52] Nonetheless, sensitivity analysis shows uptake to be an important determinant in affordability, and our analysis should be updated when results from empirical studies are available.

Our model accounts only for the effect of inhaled therapies on exacerbation rate and not for the indirect improvement in lung function.[54,55] We may observe more cost saving if this latter mechanism were accounted for, as patients would be less likely to progress to more severe disease stages.

There is uncertainty in how the time-related cost would be billed. Since we assume case detection to be administered during routine primary care visits, it may not result in a budget
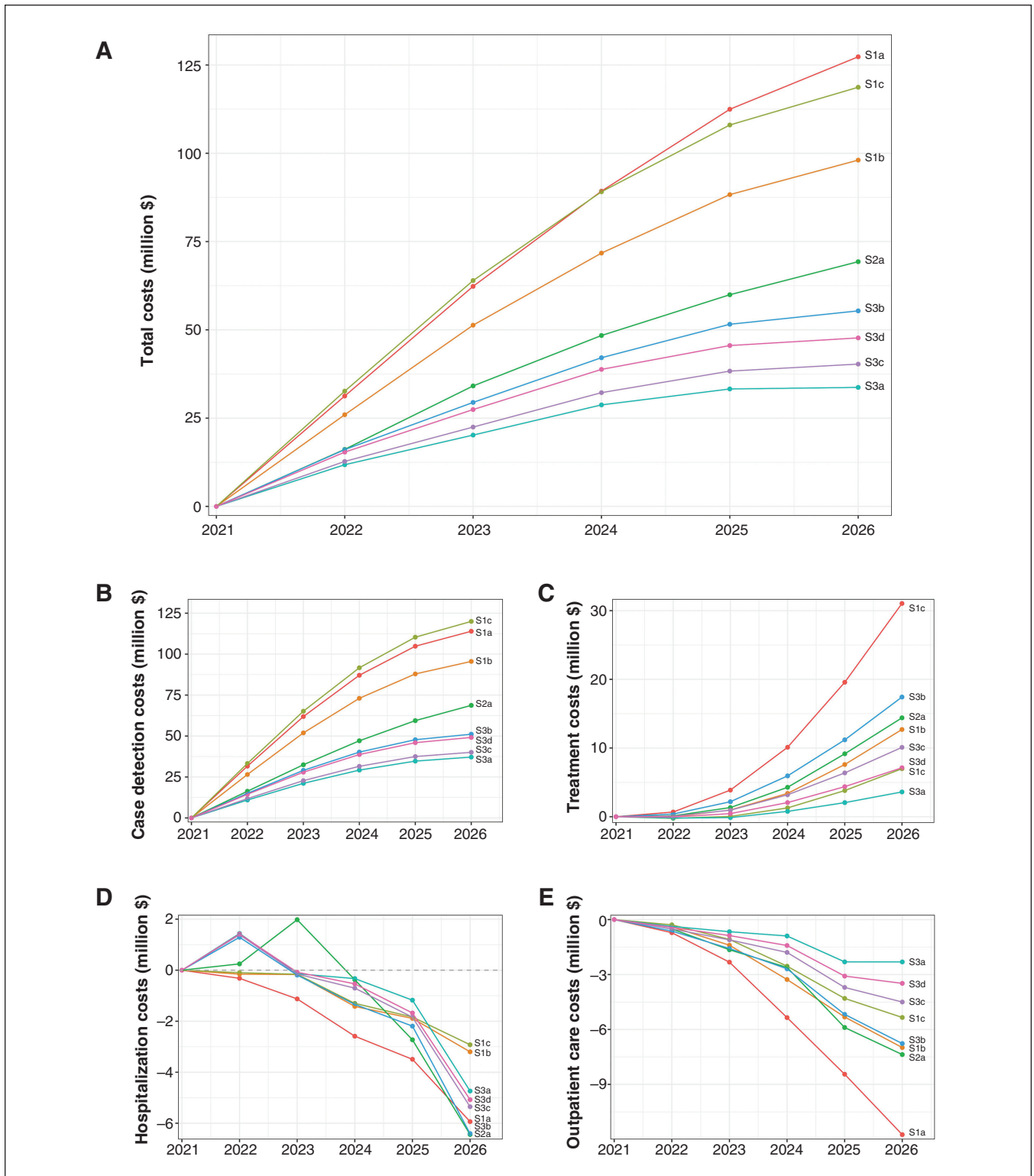
Figure 2: Annual total (A), case detection (B), treatment (C), hospitalization (D), and outpatient care (E) additional costs (million $) compared with no-case-detection baseline scenario. Negative additional costs indicate cost savings. S1a CDQ ≥ 17 points for all patients; S1b flow metre (with bronchodilator) all patients; S1c CDQ ≥ 17 points + flow metre (with bronchodilator) all patients; S2a flow metre (without bronchodilator) among symptomatic patients; S3a CDQ ≥ 19.5 points among patients aged ≥ 50 years with a smoking history; S3b CDQ ≥ 16.5 points among patients aged ≥ 50 years with a smoking history; S3c flow metre (without bronchodilator) among patients aged ≥ 50 years with a smoking history, S3d CDQ ≥ 17 points + flow metre (with bronchodilator) among patients aged ≥ 50 years with a smoking history. Results based on a single run of EPIC per scenario. Corresponding results tables can be found in Appendix 1C (available at www.cmajopen.ca/content/11/6/E1048/suppl/DC1). Note: CDQ = COPD Diagnostic Questionnaire, COPD = chronic obstructive pulmonary disease, EPIC = Evaluation Platform in COPD.
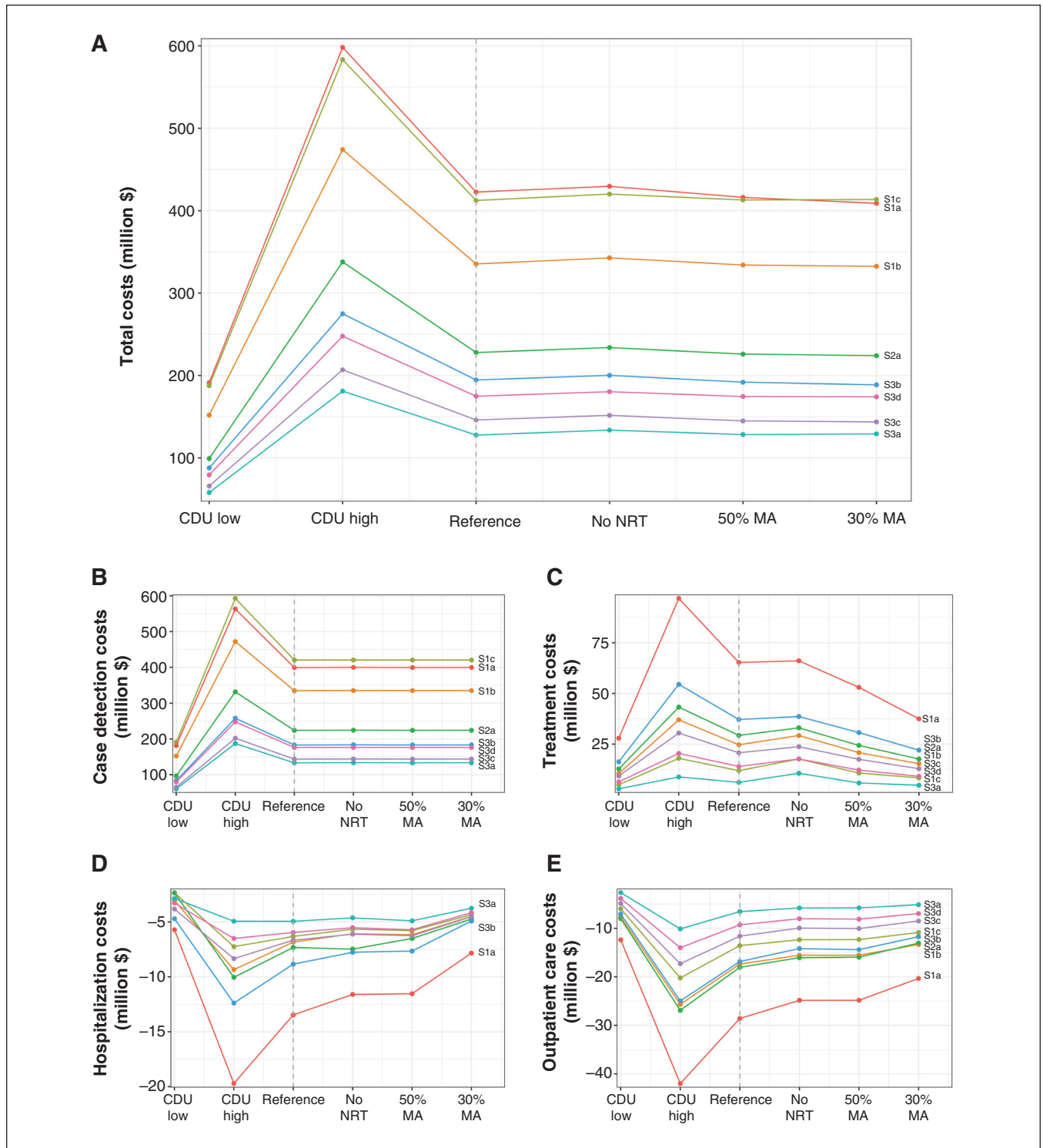
Figure 3: Sensitivity analysis results for annual total (A), case detection (B), treatment (C), hospitalization (D) and outpatient care (E) additional costs (million $) compared with no case detection. Negative additional costs indicate cost savings. Grey dashed line indicates the reference case analysis. Case detection uptake (CDU; low uptake defined as 2% to 10% range with 2%/yr increase and high uptake as 8% to 40% range with 8%/yr increase). S1a CDQ ≥ 17 points for all patients; S1b flow metre (with bronchodilator) all patients; S1c CDQ ≥ 17 points + flow metre (with bronchodilator) all patients; S2a flow metre (without bronchodilator) among symptomatic patients; S3a CDQ ≥ 19.5 points among patients aged ≥ 50 years with a smoking history; S3b CDQ ≥ 16.5 points among patients aged ≥ 50 years with a smoking history; S3c flow metre (without bronchodilator) among patients aged ≥ 50 years with a smoking history, S3d CDQ ≥ 17 points + flow metre (with bronchodilator) among patients aged ≥ 50 years with a smoking history. Results based on a single run of EPIC per scenario. Note: CDQ = COPD Diagnostic Questionnaire, COPD = chronic obstructive pulmonary disease, EPIC = Evaluation Platform in COPD, NRT = nicotine replacement therapy, MA = medication adherence.

impact if it does not result in an increase in the length or number of appointments. Conversely, this time cost captures the opportunity cost for time spent administering COPD case detection during primary care visits. We separate out the time-related cost in our budget impact results for full transparency.

Finally, EPIC is a deterministic model, which means we are unable to explore uncertainty in the input parameters through probabilistic sensitivity analysis; however, results from one-way sensitivity analyses are reported.

Conclusion

Adopting a national primary care–based case detection program for COPD will require prioritization by budget holders and substantial additional investment to facilitate access to diagnostic spirometry. Case detection is an effective method for increasing the proportion of patients diagnosed with COPD, but it depends on uptake of the program in primary care.

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Data sharing: All data are publicly available from the published literature, and EPIC is open source and publicly available as an R package https://github.com/resplab/epicR. Code for reproducing this analysis can be found on https://github.com/rachaelmountain/myrepo/blob/main/BIA_results_Rmd.Rmd and an interactive Shiny Web app is available https://resplab.shinyapps.io/bia-copd-mountain-2023/.

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