

# **How effective are colorectal cancer screening programs at increasing the rate of screening in asymptomatic average-risk groups in Canada?**

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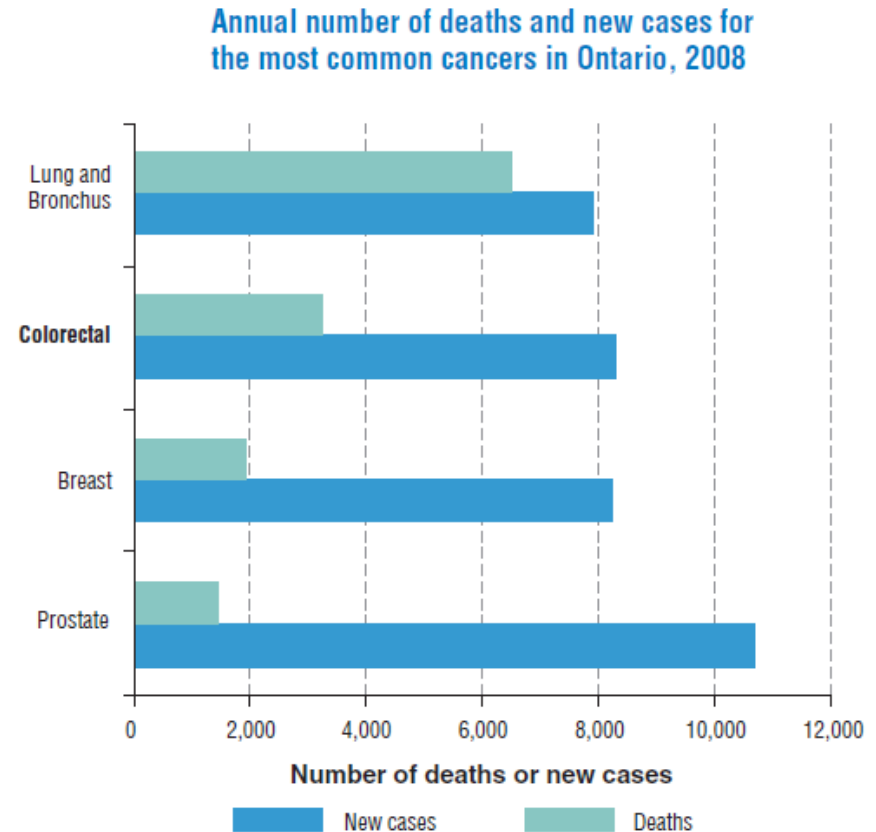
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# Colorectal Cancer in Canada

- CRC constitutes the third highest cancer incidence in Canada and the second highest cancer related mortality (Canadian Cancer Society, 2010)
- Males:
  - Incidence: 62 per 100 000
  - Death : 25 per 100 000
- Females:
  - Incidence: 41 per 100 000
  - Death : 16 per 100 000



(Cancer Care Ontario, 2008)

# Screening in Canada

- Screening Recommendations
  - Commonly have individuals  $\geq 50$  screen biennially with gFOBT with Endoscopy follow Up
  - Canadian Task Force on Preventive Healthcare (2001)
  - National Committee on Colorectal Cancer Screening (2002)
  - Canadian Association of Gastroenterology (2004)

# Screening in Canada

- 1992: 6% of those aged 50-74 reported FOBT
  - (Cancer Care Ontario, 2006)
- 2003: Screening guidelines adherence low (15.1% FOBT adherence, 30.1% total screening adherence)
  - (Sewitch et al., 2007)
- 2008: Screening adherence 23% FOBT, 40% combined
  - Significant Increases from 2005 observed in Newfoundland, New Brunswick and Ontario (not all provinces represented)
  - (Wilkins & Shields, 2008)

# ColonCancerCheck

- Asymptomatic Average Risk Population
  - ≥50 years
  - No symptoms or other bowel disorder (crohn's, colitis)
  - No Family History
- gFOBT Biennial Screening
  - Sensitivity: 50%(repeated); Specificity: 96-98%(repeated)
  - No drug/dietary restrictions except Vit. C.
  - Acceptable: complete at home and mail to CCO
- Follow-Up Colonoscopy or Flexible Sigmoidoscopy
  - (Guidice & Meuser, 2008)
- Formally Launched March 14 2008



# *ColonCancerCheck*

- Central role of Primary Care Provider (PCP)
- Five Year Media/Educational Campaign
- FOBT kits to pharmacies or TeleHealth Ontario for those without PCP
- Registry for invitations and result letters
- Sets and upholds quality assurance standards
- Additional funding for hospitals
- Development of group targeting strategies
  - (Cancer Care Ontario, 2010)



ColonCancerCheck

**YOU'RE NOT SEE-THROUGH,  
SO TALK TO YOUR HEALTH CARE PROVIDER  
ABOUT SCREENING FOR COLON CANCER**

# Study Rationale

- Previous research:
  - CRC screening has increased significantly in several provinces between 2005 -2008 including Ontario (CCHS)
  - OHIP claims data indicates increases in FOBT in 2007-8 (29.7%) from 2005-6(19.9%). 62% with positive result had endoscopy within 6 months
  - Most research has focused on proportions screened over time and predictors of screening
- Objective:
  - Evaluate the effectiveness of *ColonCancerCheck* in increasing the proportion of average risk individuals screened in a causal framework

# Methods

- Data source: Canadian Community Health Survey
  - 2003(cycle 2.1), 2005(cycle 3.1), 2007, 2008, 2009 Pooled
  - Nationally representative survey Canadians  $\geq 12$  excluding those on Indian Reserves, Crown Lands, Armed Forces, Institutions, or remote regions.
- Complex stratified cluster sampling design, unequal probabilities of selection with multiple stages of selection
  - (Statistics Canada, 2009)
- Bootstrap Re-sampling Method
  - Sample  $n-1$  clusters within each stratum with replacement
  - Form 500 replicates to recalculate survey weights with post- stratification on demographic information to correct for unequal probabilities of selection
    - (Statistics Canada, 2010)
- Pooled BS Weights rescaled proportionally for average population
  - Consistent with (Korn & Graubard , 1999)



# Methods

- Difference-in-Differences (DD)
- $Y = \beta_0 + \beta_1 * \text{Group} + \beta_2 * \text{Time} + \beta_3 * \text{Group} * \text{Time} + \varepsilon$

	Intervention Group	Control Group
Pre-Intervention		
Post-Intervention		

- $\beta_3 = [\hat{E}(Y_{igt} | T=1, G=1) - \hat{E}(Y_{igt} | T=1, G=0)] - [\hat{E}(Y_{igt} | T=0, G=1) - \hat{E}(Y_{igt} | T=0, G=0)]$
- Allows the isolation of proportion of those screened not due to fixed province (Group) differences or temporal trends (Time).
- Assumptions
  - Groups comparable in pre-intervention period, parallel slopes
  - Program is the only significant difference between groups at time of intervention, no differential period effects besides intervention

# Methods

- Regression Discontinuity Design
- Exploits threshold age of initiation (50) common to programs to create comparable treatment and control groups

$$Y_i = \beta_0 + \beta_{01} * Age_i + \beta_{0p} * Age_i^p \dots + \rho * Th_i + \beta_1 * Age_i * Th_i + \beta_p * Age_i^p * Th_i + \beta_3 * covar_{igt} + \varepsilon_i$$

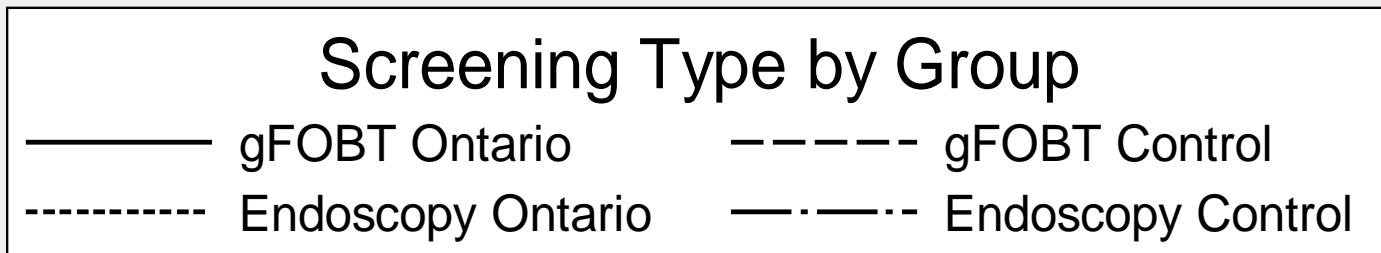
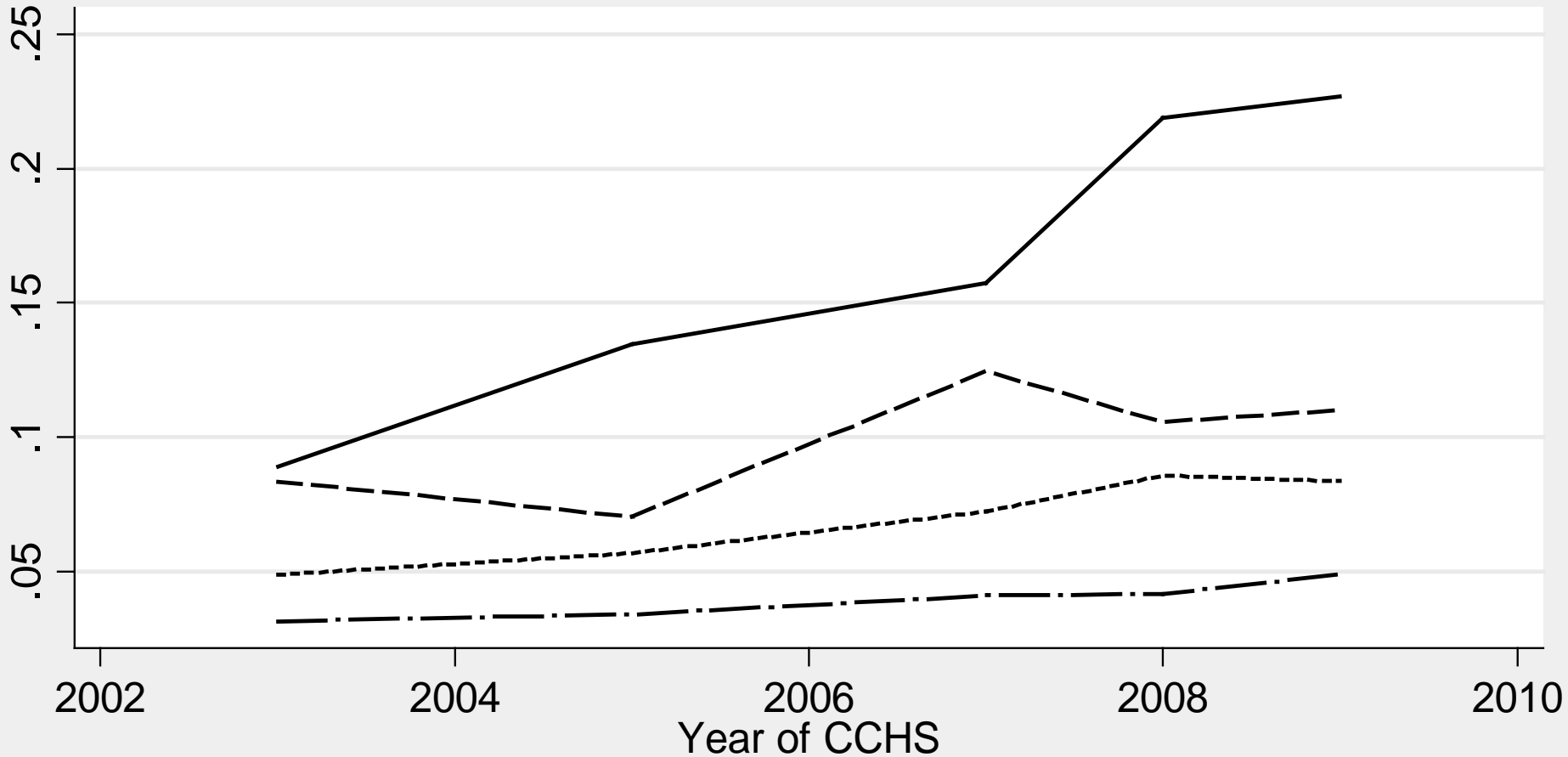
- Assumptions
  - $P[Th_i/x_i]$  is discontinuous at  $x_0$  due to Intervention only\*
  - Individuals close to threshold are similar
  - Individuals cannot manipulate or select into treatment
- \*Violated in accessing role of CCC, so expand into difference-in-difference-indifferences style analysis

$$Y_{igt} = \beta_0 + \beta_1 * Group_g + \beta_2 * Time_t + \beta_3 * Th_i + \beta_4 * Group * Time_{gt} + \beta_5 * Group * Th_{ig} + \beta_6 * Time * Th_{it} + \beta_7 * Group * Time * Th_{igt} + \beta_8 * Age_i + \beta_9 * Age_i * Th_i + \beta_{10} * covar_{igt} + \varepsilon_{igt}$$

# Sample Characteristics

- Ages 50-74
- Asymptomatic Average Risk Population
  - Excluded if report screening due to family history
  - Excluded if report screening as part of treatment
  - Excluded if report having colitis or crohn's disease
- Restricted to provinces answering optional module of questions concerning CRC screening
- Territories Restricted due to Poor Representation
- Complete Case Analysis

# Past Year Screening by Year and Group



CCHS Cycles 2.1, 3.1, 2007, 2008, 2009

# Difference in Differences Models

Outcome		DD*			DD**				
		Mrg	95% CI		p	Mrg	95% CI		p
gFOBT	Post Intervention	0.073	0.052	0.095	0.000	0.074	0.053	0.095	0.000
	Interv Group	0.082	0.059	0.104	0.000	0.064	0.041	0.086	0.000
	Group*Time	0.050	0.030	0.070	0.000	0.052	0.032	0.071	0.000
Endoscopy	Post Intervention	0.022	0.008	0.037	0.003	0.023	0.009	0.038	0.002
	Interv Group	0.018	0.005	0.031	0.006	0.009	-0.004	0.022	0.182
	Group*Time	0.007	-0.007	0.021	0.301	0.009	-0.005	0.023	0.207

CCHS 2003, 2005, 2007, 2008, 2009.

\*: main effects controlled for year and province indicators

\*\* : main effects controlled for year, province, sex, age category, geography, self rated health, having MD, reporting flu shot, physical activity index, smoking status, ethnicity, education, income, #GP consultations past year

Results shown are average marginal effects calculated from multivariate logistic regression model. Complete case analysis used.

# Difference in Difference in Differences (DDD)

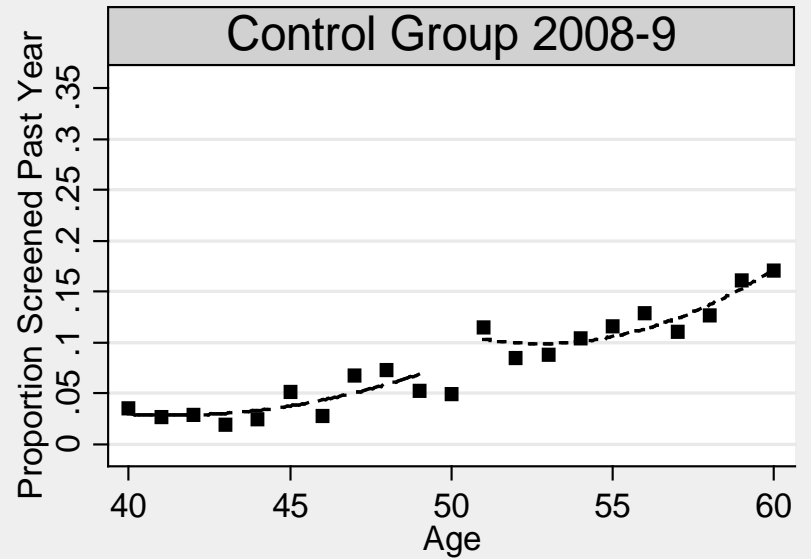
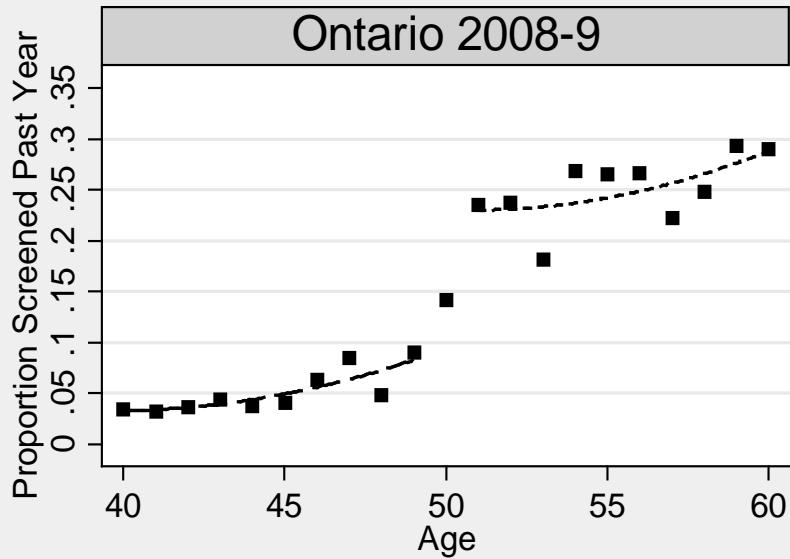
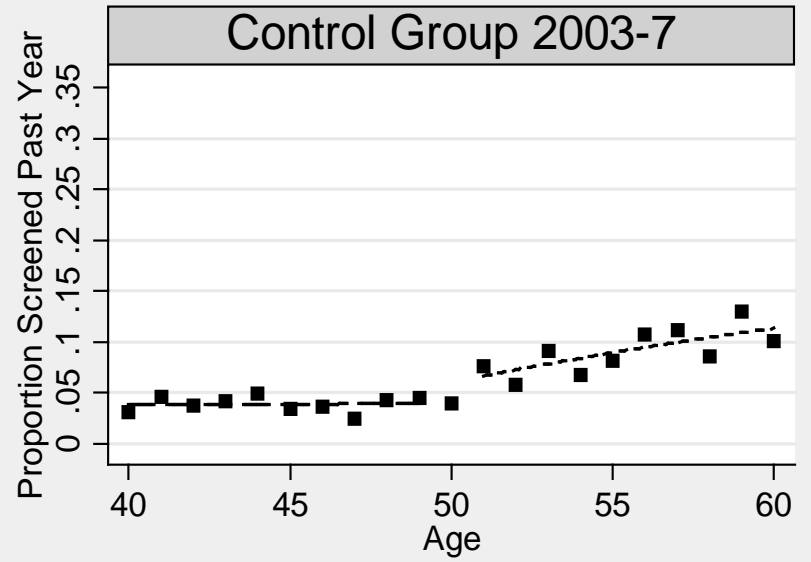
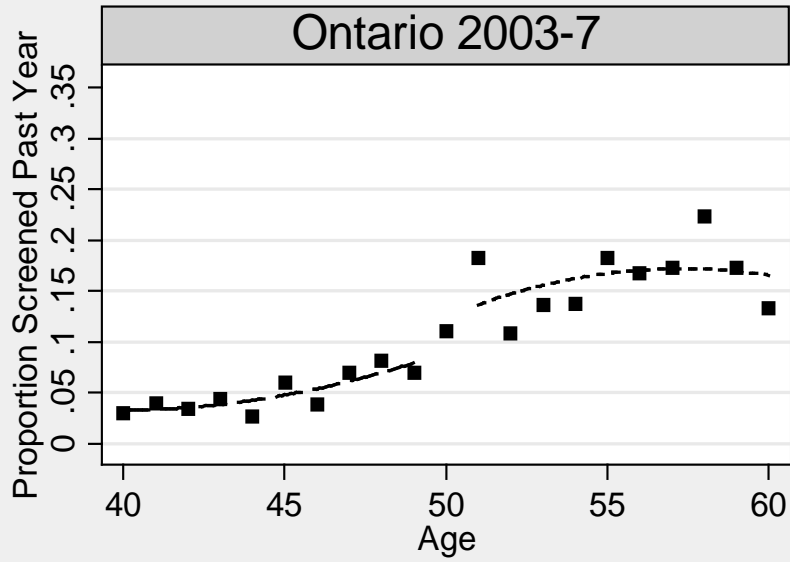
- $$Y = \beta_0 + \beta_1 * \text{Group} + \beta_2 * \text{Time} + \beta_3 * \text{Var} + \beta_4 * \text{Group} * \text{Time} + \beta_5 * \text{Group} * \text{Var} + \beta_6 * \text{Time} * \text{Var} + \beta_7 * \text{Group} * \text{Time} * \text{Var} + \varepsilon$$

Outcome		DDD*			
		Mrg Effect	95% CI		p
<b>gFOBT</b>	<b>G*T*MD</b>	0.008	-0.095	0.111	0.883
	<b>G*T*Age65-74</b>	0.028	-0.008	0.065	0.127
	<b>G*T*PhysInactive</b>	0.007	-0.029	0.042	0.720
	<b>G*T*Flu-Shot</b>	0.010	-0.031	0.052	0.623
<b>Endoscopy</b>	<b>G*T*MD</b>	0.065	-0.007	0.137	0.077
	<b>G*T*Age65-74</b>	0.002	-0.022	0.027	0.853
	<b>G*T*PhysInactive</b>	-0.003	-0.027	0.022	0.835
	<b>G*T*Flu-Shot</b>	-0.007	-0.035	0.021	0.628

CCHS 2003, 2005, 2007, 2008, 2009.

\*: main effects controlled for year, province, sex, age category, geography, self rated health, having MD, reporting flu shot, physical activity index, smoking status, ethnicity, education, income, #GP consultations past year

Results shown are average marginal effects calculated from multivariate logistic regression model. Complete case analysis used.



# RDD-Expansion

Outcome	Model	Mrg Effect	95% CI		p	Bandwidth
<b>gFOBT</b>	1	0.0104	-0.0245	0.0453	0.558	40-60
	2	0.0119	-0.0225	0.0463	0.499	40-60
	3	0.0456	-0.0040	0.0953	0.072	45-55
	4	0.0451	-0.0035	0.0938	0.069	45-55
<b>Endoscopy</b>	1	-0.0067	-0.0283	0.0149	0.544	40-60
	2	-0.0063	-0.0278	0.0152	0.566	40-60
	3	-0.0103	-0.0396	0.0189	0.489	45-55
	4	-0.0097	-0.0386	0.0192	0.510	45-55

CCHS 2003, 2005, 2007, 2008, 2009

Models 1 and 3: main effects controlled for year and province

Models 2 and 4: main effects controlled for year, province, sex, age category, geography, self rated health, having MD, reporting flu shot, physical activity index, smoking status, ethnicity, education, income, #GP consultations past year

Models 1-2: linear age term, Models 3-4: squared age term

Results shown are average marginal effects calculated from multivariate logistic regression model. Complete case analysis used



# Limitations

Province	2003	2005	2007	2008	2009
Newfoundland and Labrador	•	•	•	•	•
Prince Edward Island		•	•	•	•
Nova Scotia		•		•	•
New Brunswick		•		•	•
Quebec				•	
Ontario	○	•	•	•	•
Manitoba				•	
Saskatchewan	○		•	•	•
Alberta				•	
British Columbia	•			•	

- Suitability of Control Group

○ Indicates not all health regions were surveyed for this province.

- Different Pre-intervention Screening Trends
- Unbalanced panel of control provinces
- Number of provinces and years do not allow adjustment for province-specific time trends
- Membership of control group disproportionately represents Eastern Canada, which typically has lower screening rates

# Limitations

- Unmeasured Interactions
  - DD falsification analysis (pseudo-treatment year)
  - DDD analyses to test for potential interactions
- Risk of endogeneity of policy adoption
  - Conditions which brought about policy have independent effect on subsequent policy outcomes
  - National screening guidelines for consistency
  - Federal transfers to provinces, guarantees for reasonable access to care, harmonized training of health professionals
  - Avoids greatest disparities by excluding territories
  - Upcoming programs in Alberta and Manitoba

# Bias Check 1: DD Before Intervention

Outcome		DD*				DD**			
		Mrg Effect	95% CI		p	Mrg Effect	95% CI		p
Combined	2007	<b>0.076</b>	<b>0.040</b>	<b>0.113</b>	<b>0.000</b>	<b>0.077</b>	<b>0.042</b>	<b>0.112</b>	<b>0.000</b>
	Treatment Group	<b>0.090</b>	<b>0.064</b>	<b>0.115</b>	<b>0.000</b>	<b>0.067</b>	<b>0.041</b>	<b>0.093</b>	<b>0.000</b>
	Group*Time	0.008	-0.031	0.048	0.675	0.008	-0.031	0.046	0.689
FOBT	2007	<b>0.086</b>	<b>0.053</b>	<b>0.120</b>	<b>0.000</b>	<b>0.088</b>	<b>0.055</b>	<b>0.120</b>	<b>0.000</b>
	Treatment Group	<b>0.084</b>	<b>0.060</b>	<b>0.109</b>	<b>0.000</b>	<b>0.069</b>	<b>0.044</b>	<b>0.094</b>	<b>0.000</b>
	Group*Time	-0.019	-0.055	0.017	0.295	-0.020	-0.056	0.015	0.256
Endoscopy	2007	-0.001	-0.022	0.020	0.959	0.000	-0.020	0.021	0.989
	Treatment Group	<b>0.019</b>	<b>0.004</b>	<b>0.034</b>	<b>0.015</b>	0.010	-0.005	0.025	0.198
	Group*Time	0.022	-0.001	0.045	0.065	0.022	-0.001	0.045	0.061

CCHS 2003, 2005 (pre-intervention), 2007 (post-intervention).

\*: main effects controlled for year and province indicators

\*\*: main effects controlled for year, province, sex, age category, geography, self rated health, having MD, reporting flu shot, physical activity index, smoking status, ethnicity, education, income, #GP consultations past year

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## Bias Check 2: DD Alternate Outcome (Flu shot)

Outcome		DD*				DD**			
		Mrg Effect	95% CI		p	Mrg Effect	95% CI		p
Flu shot	Post Intervention	<b>0.066</b>	<b>0.036</b>	<b>0.096</b>	<b>0.000</b>	<b>0.074</b>	<b>0.045</b>	<b>0.103</b>	<b>0.000</b>
	Treatment Group	<b>0.273</b>	<b>0.250</b>	<b>0.295</b>	<b>0.000</b>	<b>0.259</b>	<b>0.237</b>	<b>0.281</b>	<b>0.000</b>
	Group*Time	-0.015	-0.045	0.014	0.305	-0.015	-0.044	0.013	0.291

CCHS 2003, 2005, 2007, 2008, 2009.

\*: main effects controlled for year and province indicators

\*\* : main effects controlled for year, province, sex, age category, geography, self rated health, having MD, reporting flu shot, physical activity index, smoking status, ethnicity, education, income, #GP consultations past year

Results shown are average marginal effects calculated from multivariate logistic regression model. Complete case analysis used.

# Limitations

- Time of Program Initiation
  - Manitoba and Alberta 2008 had pilot programs in place which may distort results in this year
  - Official launch Mar 2008 but attributes of program likely in place at earlier time
  - Data from CCHS 2008 may be for events prior to launch
- Inaccuracy of self-reported outcomes
  - FOBT sensitivity 82%, specificity 78%; tendency to under-report (Rauscher et al., 2008)
- *ColonCancerCheck* roll-out is ongoing and aspects of the program yet to be implemented.

# Strengths

- DD distinguishes causal effect:
  - Control for temporal trends (shown to increase)
  - Confounders common to both treatment groups
  - Reduce bias due to differences between provincial healthcare systems
- DD Reduces measurement error
- RDD approximates random sampling
  - Greater internal validity
  - Reduces risk of confounding

# Strengths

- Canadian Community Health Survey
  - Relatively consistent over time
  - Detailed screening data
  - Detailed information on relevant health and socio-demographic data
  - Covered all of Canada over large time range
- Repeated cross-sections vs. panel data
  - Avoid problem of loss to follow-up
  - More representative of community level changes
  - Alleviates variance miscalculation by correlation of residuals

# Conclusions

- Some evidence suggests *ColonCancerCheck* increases past-year screening in asymptomatic average risk adults up to absolute increase of 5.2 percentage points.
- Effect of *ColonCancerCheck* seen mostly through FOB testing
- Results reinforce previous research on importance of PCP
- Insufficient evidence to state that dynamics of demographic predictors of screening have been altered upon introduction of *ColonCancerCheck*
- Convincing evidence of program effect at the threshold
- More consistent data on screening in provinces would lead to more robust analysis and greater confidence in results



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# References

- Canadian Cancer Society. (May 19 2010). Colorectal Cancer Statistics Retrieved July 10, 2010, from [http://www.cancer.ca/Canada-wide/About%20cancer/Cancer%20statistics/Stats%20at%20a%20glance/Colorectal%20cancer.aspx?sc\\_lang=en](http://www.cancer.ca/Canada-wide/About%20cancer/Cancer%20statistics/Stats%20at%20a%20glance/Colorectal%20cancer.aspx?sc_lang=en)
- Canadian Partnership Against Cancer. (2009). *The System Performance Initiative: The First Year Report*. Toronto: Retrieved from [http://www.cancerview.ca/idc/groups/public/documents/webcontent/system\\_performance\\_pdf.pdf](http://www.cancerview.ca/idc/groups/public/documents/webcontent/system_performance_pdf.pdf).
- Canadian Task Force on Preventive Health Care. (2001). Colorectal cancer screening: Recommendation statement from the Canadian Task Force on Preventive Health Care. *Canadian Medical Association Journal*, 165(2), 206-208.
- Cancer Care Ontario. (2006). *Ontario FOBT Project Final Report*. Toronto: Retrieved from <http://www.cancercare.on.ca/common/pages/UserFile.aspx?fileId=13608>.
- Cancer Care Ontario. (2008). *Insight on Cancer: News and Information on Colorectal Cancer and Screening in Ontario*. Toronto: Retrieved from <http://www.cancercare.on.ca/common/pages/UserFile.aspx?fileId=34627>.
- Cancer Care Ontario. (2010). *Colon Cancer Check 2008 Program Report*. Toronto: Retrieved from <http://www.cancercare.on.ca/common/pages/UserFile.aspx?fileId=75573>.
- CancerCare Manitoba. (2010). *Cancer in Manitoba Incidence and Mortality 2007 Annual Statistical Report* Winnipeg.
- Guidice, L. D., & Meuser, J. (2008). Colorectal Cancer Screening, from <http://www.health.gov.on.ca/en/pro/programs/coloncancercheck/screeningresearch.aspx>
- Hewitson, P., Glasziou, P., Watson, E., Towler, B., & Irwig, L. (2008). Cochrane systematic review of colorectal cancer screening using the fecal occult blood test (hemoccult): an update. *American Journal of Gastroenterology*, 103(6), 1541-1549.
- Leddin, D., Hunt, R., Champion, M., Cockeram, A., Flook, N., Gould, M., . . . Canadian Digestive Health Foundation. (2004). Canadian Association of Gastroenterology and the Canadian Digestive Health Foundation: Guidelines on colon cancer screening. *Canadian Journal of Gastroenterology*, 18(2), 93-99.
- National Committee on Colorectal Cancer Screening. (2002). *Recommendations for population-based colorectal cancer screening*. Retrieved from <http://www.phac-aspc.gc.ca/publicat/ncccs-cndcc/ccsrec-eng.php>
- Rauscher, GH, Johnson TP, Cho YI, et al. Accuracy of self-reported cancer screening histories: a meta-analysis. *Cancer Epidemiology Biomarkers & Prevention*. 2008; 17(4):748-757.
- Ries, L. A. G., Wingo, P. A., Miller, D. S., Howe, H. L., Weir, H. K., Rosenberg, H. M., . . . Edwards, B. K. (2000). The annual report to the nation on the status of cancer, 1973–1997, with a special section on colorectal cancer. *Cancer*, 88(10), 2398-2424.
- Sewitch, M.J., Fournier, C., Ciampi, A., Dyachenko, A. (2007). Adherence to colorectal cancer screening guidelines in Canada. *BMC Gastroenterology*, 7, 39.
- Statistics Canada (2010). *Canadian Community Health Survey (CCHS)-Annual Component User Guide 2009 Microdata Files*. Retrieved Sept 1 2010 From: [http://www.statcan.gc.ca/cgi-bin/af-fdr.cgi?l=eng&loc=http://www.statcan.gc.ca/imdb-bmdi/document/3226\\_D7\\_T9\\_V7-eng.pdf&teng=CCHS%202009%20User%20Guide&tfra=ESCC%202009%20Guide%20de%20l'utilisateur](http://www.statcan.gc.ca/cgi-bin/af-fdr.cgi?l=eng&loc=http://www.statcan.gc.ca/imdb-bmdi/document/3226_D7_T9_V7-eng.pdf&teng=CCHS%202009%20User%20Guide&tfra=ESCC%202009%20Guide%20de%20l'utilisateur)
- Statistics Canada (2010). *Canadian Community Health Survey (CCHS)*. Retrieved Sept 1 2010, from <http://www.statcan.gc.ca/cgi-bin/imdb/p2SV.pl?Function=getSurvey&SDDS=3226&lang=en&db=imdb&adm=8&dis=2>.
- Korn E.L., & Graubard, B.I. (1999). *Analysis of Health Surveys*. New York: Wiley. p 278-301.
- Winawer, S. J. (1999). Natural history of colorectal cancer. *The American Journal of Medicine*, 106(1, Supplement 1), 3-6. doi: Doi: 10.1016/s0002-9343(98)00338-6
- Wilkins, K., & Shields, M. (2009). Colorectal cancer testing in Canada--2008. *Health Reports*, 20(3), 21-30.