

Supplementary Online Content

Bhatia RS, Buock Z, Ivers NM, et al. Electrocardiograms in low-risk patients undergoing an annual health examination [published online July 10, 2017]. *JAMA Intern Med*. doi:10.1001/jamainternmed.2017.2649

eAppendices. Search strategy for Medline (using PubMed)

This supplementary material has been provided by the authors to give readers additional information about their work.

APPENDIX 1

INCLUSION CRITERIA

Index event

- Adult patients (age 18+) with an OHIP claim for a periodic health visit (FEECODE = K131, K132) or annual health examination (A003 with DXCODE = 917) with a family physician (SPEC = 00 = “Family practice and general practice”) occurring within April 1st, 2010 and March 31st, 2014
- Only the first eligible visit/examination was included in analysis

Outcomes

Primary outcome

Receipt of an electrocardiogram – claim in OHIP with fee code G310 or G313 within 30 days of index event

Note: where an ECG was claimed on the same day as an emergency department visit [NACRS], the tests were not counted as they may have been conducted as part of ED or hospital admissions screening process.

Secondary outcomes

Additional testing or procedures – any of the following claimed within 3 months of index event:

- Visits to cardiologists or cardiac surgeons: see related high-risk exclusion(s) for codes
- Transthoracic echocardiogram:
 - [OHIP] fee codes = G560, G561, G562, G566, G567, G568, G570, G571, G572, G574, G575, G576, G577, G578
- Cardiac stress test:
 - *Stress test*: [OHIP] fee codes = maximal stress ECG (G315, G319), stress echocardiogram (G582, G583, G584)
 - *Nuclear stress test*: [OHIP] fee codes = dobutamine stress test (G174), dipyramide Thallium stress test (G111, G112), myocardial perfusion scintigraphy (J607, J807, J608, J808, J609, J809, J666, J866)
- Cardiac catheterization procedure: [OHIP] fee codes: Z439 to G288

Tertiary outcomes

Adverse outcomes – any of the following claimed within 12 months of index event:

- Death [RPDB] – DTHDATE within 12 months of index event
- Cardiac-related hospitalization: [DAD] at least 1 admission with the following ICD-10 codes:
 - Coronary artery disease: I20, I21, I22, I23, I24, I25; atrial fibrillation/flutter: I48; other cardiac arrhythmia: I44, I45, I46, I47, I49; cardiac valvular disease: I05, I06, I07, I08, I09.1, I09.8, I34, I35, I36, I37, I38; heart failure: I50; venous thromboembolism: I80.1, I80.2, I80.8, I82.2, I82.3, I82.8, I82.9
 - Symptoms and signs involving the circulatory and respiratory systems, not elsewhere classified: R00 = abnormalities of heart beat; R01 = cardiac murmurs and other cardiac sounds; R03 = abnormal blood pressure reading, without diagnosis; R06 = abnormalities of breathing; R07 = pain in throat and chest; R09 = other symptoms and signs involving the circulatory and respiratory system
- Coronary revascularization (PCI or CABG):
 - [DAD] CCI codes: PCI (1IJ50, 1IJ57); CABG (1IJ76)
 - [OHIP] fee codes Z434, Z448, Z449, Z460, Z461, R742, R743

EXCLUSION CRITERIA

Long-term care resident

- Lookback one year from index event and exclude if any OHIP claims with LOCATION='L' or ODB claims with LTC='1'

High-risk exclusions

Note: Patients excluded if they met any of the following criteria within three years prior of their index event (unless otherwise noted*).

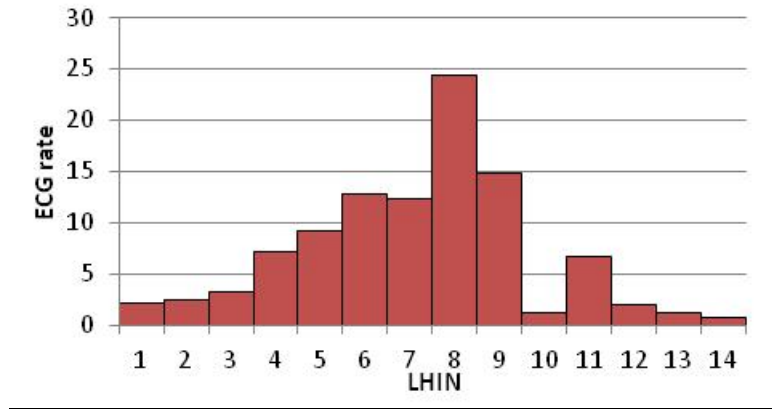
<i>Cardiovascular signs, symptoms, and diagnoses – two or more physician claims with the following diagnostic codes within a two year period in OHIP data</i>			
398	Other rheumatic heart disease	401-402	Essential, benign hypertension; hypertensive heart disease
410	Acute myocardial infarction	412	Old myocardial infarction, chronic coronary artery disease or arteriosclerotic heart disease, without symptoms
413	Acute coronary insufficiency, angina pectoris, acute ischaemic heart disease	415	Pulmonary embolism, pulmonary infarction
426	Heart blocks, other conduction disorders	427	Paroxysmal tachycardia, atrial or ventricular flutter of fibrillation, cardiac arrest, other arrhythmias
428	Congestive heart failure	429	All other forms of heart disease (e.g. pericarditis)
746	Other congenital anomalies of the heart (includes acute congenital heart disease)	785	Chest pain, tachycardia, syncope, shock, edema, masses
<i>Cardiovascular signs, symptoms, and diagnoses – one or more hospital admissions with the following ICD-10 codes in CIHI-DAD data</i>			
I20-I25	Coronary artery disease	I48	Atrial fibrillation/flutter
I44-I49	Other cardiac arrhythmia	I05-I08, I09.1, I09.9, 134-I38	Cardiac valvular disease
I80.1, I80.2, 180.8, 182.2, I82.3, I82.8, I82.9	Venous thromboembolism	R00	Abnormalities of heart beat
R01	Cardiac murmurs and other cardiac sounds	R03	Abnormal blood pressure reading, without diagnosis
R06	Abnormalities of breathing	R07	Pain in throat and chest
R09	Other symptoms and signs involving the circulatory and		

	respiratory system		
<i>Cerebrovascular and peripheral vascular disease diagnoses – two or more physician claims with the following diagnostic codes within a two year period in OHIP data</i>			
432	Intracranial haemorrhage	435	Transient cerebral ischaemia
436	Acute cerebrovascular accident, C.V.A, stroke	437	Chronic arteriosclerotic cerebrovascular disease, hypertensive encephalopathy
440	Generalized arteriosclerosis, athlerosclerosis	441	Aortic aneurysm (non-syphilitic)
443	Raynaud’s disease, Buerger’s disease, peripheral vascular disease, intermittent claudication		Polyarteritis nodosa, temporal arteritis
446	Other disorders of the arteries	451	Phlebitis, thrombophlebitis
452	Portal vein thrombosis		
<i>Cerebrovascular and peripheral vascular disease diagnoses – one or more hospital admissions with the following ICD-10 codes in CIHI-DAD data</i>			
I60, I61, I63, I64, G45, G46, H34		Previous cerebrovascular disease	
I70, I71, I73.1, I73.8, I73.9, I77.1, I79.0, I79.2, K55.1, K55.8, K55.9, Z95.8, Z95.9		Peripheral vascular disease	
I80.1, I80.2, I80.8, I82.2, I82.3, I82.8, I82.9		Venous thromboembolism	
Signs, symptoms, and conditions associated with a high-risk of CVD – two or more physician claims with the following diagnostic codes within a two year period in OHIP data			
042-044	AIDS, AIDS-related complex (A.R.C.), or other human immunodeficiency virus infection	403	Hypertensive renal disease
584	Acute renal failure	585	Chronic renal failure, uremia
Signs, symptoms & conditions associated with a high-risk of CVD – one or more hospital admissions with the following ICD-10 codes in CIHI-DAD data			
B20-B24		Human immunodeficiency virus	
I12, I13, N03.2-N03.7, N05.2-N05.7, N17, N18, N19, N25.0, Z49, Z94.0, Z99.2		Chronic renal disease	
Signs, symptoms & conditions associated with a high-risk of CVD – any of the following at any point prior to cohort entry*:			
<ul style="list-style-type: none"> Heart failure diagnosis indicated in Congestive Heart Failure (CHF) database 			

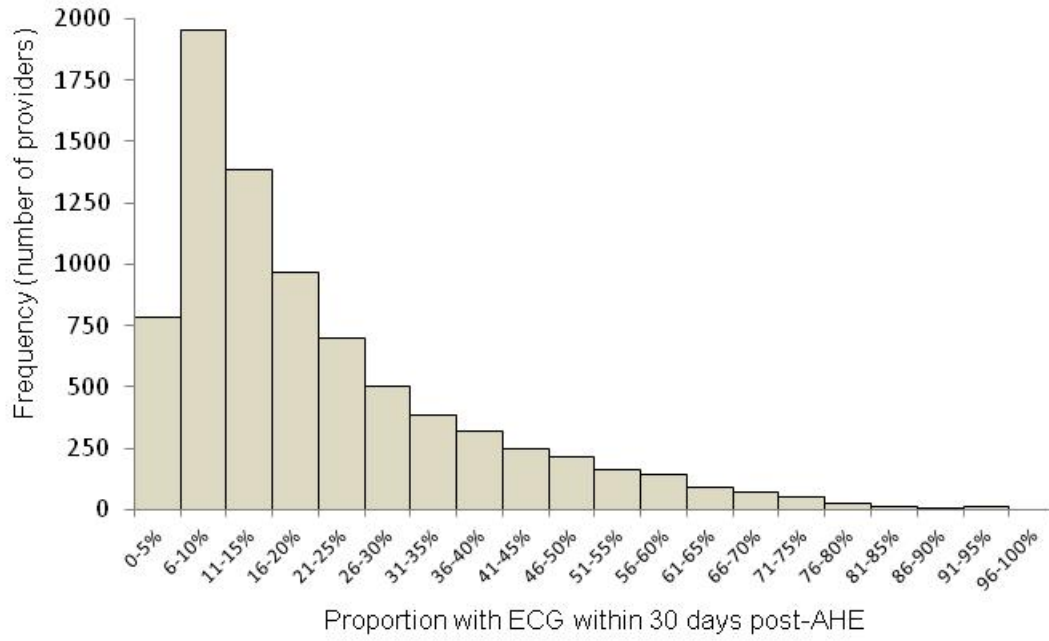
<ul style="list-style-type: none"> • Diabetes diagnosis indicated in Ontario Diabetes Database (ODD) • Hypertension diagnosis indicated in HYPER 			
Prior visits to cardiologists of cardiac surgeons – one or more OHIP claims with the following fee codes:			
<i>Cardiology outpatient visit</i>			
A600	Comprehensive cardiology consultation	A601	Complex medical specific re-assessment
A603	Medical specific assessment	A604	Medical specific re-assessment
A605	Consultation	A606	Repeat consultation
A608	Partial assessment	A675	Limited consultation
<i>Cardiothoracic surgery outpatient visit</i>			
A093	Specific assessment	A094	Partial assessment
A095	Consultation	A096	Repeat consultation
A935 (with SPEC=09)	Special surgical consultation		
<i>Non-emergency hospital inpatient visit with MRP being a cardiologist (SPEC=60) or cardiothoracic surgeon (SPEC=09)</i>			
C600	Comprehensive cardiology consultation	C601	Complex medical specific re-assessment
C602	subsequent visits, first 5 weeks	C603	Medical specific assessment
C604	Medical specific re-assessment	C605	Consultation
C606	Repeat consultation	C607	subsequent visits, 6 th -13 th week
C608	subsequent visits by MRP following transfer from ICU, concurrent care	C609	subsequent visits, after 13 th week
C121	subsequent visits by MRP following transfer from ICU, additional visits due to intercurrent illness	C122	subsequent visits by MRP, day following admission assessment
C123	subsequent visit by MRP, second day following hospital assessment	C124	day of discharge
C142	subsequent visits by MRP following transfer from ICU, 1 st subsequent visit	C143	subsequent visits by MRP following transfer from ICU, 2 nd subsequent visit
C675	Limited consultation		

C935 (with SPEC=09 only)	Special surgical consultation		
Prior cardiac procedures – any of the following based OHIP fee codes			
R738, R863	Aortic valve replacement	R735	Mitral valve replacement
Z434, R742, R743	Coronary artery revascularization	R761, R753, R752	Device implantation
Prior cardiac procedures – any of the following based OHIP fee codes			
1HV90	Aortic valve replacement	1HU90	Mitral valve replacement
1IJ26, 1IJ50, 1IJ55, 1IJ57, 1IJ76, 1IJ80	Coronary artery revascularization	1HZ53GRFS, 1HZ53LAFS, 1HZ53GRNM, 1HZ53LANM, 1HZ53GRNK, 1HZ53LANK, 1HZ53GRNL, 1HZ53LANL, 1HZ53GRFR, 1HZ53LAFR	Device implantation

Appendix 2.0: Rates of ECG ordering by region (Local Health Integration Network)



Appendix 2.1: Rates of ECG ordering by primary care provider



Appendix 2.2. Association between patient- and provider-level characteristics and having a potentially low-value ECG on the same day as an annual health examination ($N = 2\,873\,357$)

<u>Fixed Effects</u>	Odds Ratio ^a (95% CI)
<i>Patient characteristics</i>	
Age group	
45-64 y v 18-44 y	3.02 (2.99-3.04)*
≥ 65 y v 18-44 y	3.72 (3.66-3.79)*
Male	1.06 (1.05-1.07)*
Rural	0.73 (0.72-0.75)*
Neighbourhood income quintile	
2 v 1 (lowest)	1.10 (1.09-1.12)*
3 v 1 (lowest)	1.13 (1.12-1.15)*
4 v 1 (lowest)	1.15 (1.14-1.17)*
5 v 1 (lowest)	1.14 (1.12-1.15)*
Hospital admission in past 3 y	1.00 (0.98-1.02)
Cancer	1.37 (1.35-1.38)*
COPD	1.02 (1.01-1.05)*
Asthma	0.86 (0.85-0.87)*
Mental health	1.03 (1.02-1.04)*
Dementia	0.85 (0.80-0.92)*
Rheumatologic disease	1.18 (1.16-1.21)*
<i>Provider characteristics</i>	
Male	1.24 (1.23-1.25)*
IMG	1.09 (1.08-1.10)*
Years since graduation (mean)	
21-30 y vs 0-20 y	1.03 (1.02-1.04)*
> 30 y v 0-20 y	1.17 (1.16-1.19)*
Organizational structure	

Family health group v FFS	1.68 (1.65-1.70)*
Family health network v FFS	1.07 (0.86-1.34)
Family health organization v FFS	1.35 (1.31-1.40)*
Family health team v FFS	0.94 (0.90-0.98)
Other v FFS	1.93 (1.85-2.02)*
Practice	3.02 (2.88-3.17)*, ^a

Note: * $p < .05$; CI = confidence interval; all reported values based on SAS PROC GLIMMIX output; model estimation method = RSPL; denominator degrees of freedom estimation method = between and within (bw); covariance structure = standard variance (vc).

^a All odds ratios presented are adjusted for all other factors in the table.

^b Median odds ratio reported with 95% CI in parentheses.

Appendix 2.3 Descriptive statistics for downstream cardiac tests and consultations occurring with 12 months of index annual health examination (n = 3 629 859).

Clinical outcome	No. without ECG in 30 d (%) (n = 2 851 524)	No. with ECG in 30 d (%) (n = 778 335)
Cardiac consultations, n (%)	24 687 (0.87%)	32 589 (4.19%)
Transthoracic echocardiograms, n (%)	45 541 (1.60%)	76 282 (9.80%)
Cardiac stress tests, n (%)	23 897 (0.84%)	38 045 (4.89%)
Nuclear stress tests, n (%)	9 182 (0.32%)	13 348 (1.71%)
Cardiac catheterizations, n (%)	778 (0.03%)	2 253 (0.29%)

Appendix 2.4. Patient- and provider-level indicators for a downstream cardiac consultation, test or procedure within 3 months after an annual health examination, with or without a same day ECG: *N* = 2 352 324.

	Cardiac consultations	TTE	Nuclear stress test
<u>Fixed Effects</u>	OR ^a (95% CI)	OR ^a (95% CI)	OR ^a (95% CI)
<i>Patient characteristics</i>			
ECG by AHE on the same day	1.58 (1.54-1.63)*	1.95 (1.91-1.98)*	1.74 (1.67-1.81)*
Physician ECG ordering quintile			
2 v 1 (lowest)	1.19 (1.14-1.24)*	1.39 (1.34-1.44)*	1.14 (1.06-1.23)*
3 v 1 (lowest)	1.36 (1.30-1.42)*	1.80 (1.73-1.86)*	1.35 (1.25-1.45)*
4 v 1 (lowest)	1.31 (1.26-1.38)*	2.07 (1.99-2.14)*	1.51 (1.41-1.63)*
5 v 1 (lowest)	0.92 (0.88-0.97)*	1.63 (1.57-1.69)*	1.27 (1.17-1.37)*
Age group			
45-64 y v 18-44 y	2.13 (2.08-2.18)*	1.74 (1.71-1.77)*	4.35 (4.17-4.53)*
≥ 65 y v 18-44 y	4.06 (3.92-4.20)*	3.02 (2.94-3.09)*	8.58 (8.13-9.05)*
Male	1.88 (1.84-1.92)*	1.34 (1.32-1.36)*	1.40 (1.35-1.45)*
Neighbourhood income quintile			
2 v 1 (lowest)	1.02 (0.98-1.05)	0.91 (0.89-0.93)*	0.96 (0.91-1.01)
3 v 1 (lowest)	1.02 (0.98-1.05)	0.93 (0.91-0.95)*	0.94 (0.89-0.99)*
4 v 1 (lowest)	1.04 (1.01-1.07)*	0.90 (0.87-0.91)*	0.96 (0.91-1.01)
5 v 1 (lowest)	1.04 (1.01-1.08)*	0.90 (0.88-0.92)*	0.94 (0.89-0.99)*

Hospital admission last 3 y	1.41 (1.35-1.47)*	0.90 (0.87-0.93)*	0.98 (0.91-1.06)
Cancer	1.83 (1.78-1.89)*	1.17 (1.14-1.19)*	1.84 (1.76-1.91)*
COPD	1.15 (1.10-1.21)*	1.04 (1.01-1.08)*	1.24 (1.17-1.32)*
Asthma	1.03 (1.00-1.07)	0.95 (0.93-0.98)*	0.99 (0.94-1.04)
Mental health	1.21 (1.18-1.25)*	0.97 (0.95-0.99)*	1.07 (1.02-1.12)*
Dementia	1.40 (1.24-1.58)*	0.93 (0.84-1.05)	0.97 (0.79-1.19)
Rheumatologic disease	1.51 (1.45-1.57)*	1.09 (1.05-1.13)*	1.26 (1.18-1.34)*
Rural	1.00 (0.97-1.05)	0.96 (0.92-0.99)*	0.85 (0.79-0.92)*
<i>Provider characteristics</i>			
Male	0.94 (0.91-0.96)*	0.98 (0.96-0.99)*	1.06 (1.02-1.10)*
IMG	1.15 (1.12-1.18)*	1.17 (1.15-1.19)*	1.21 (1.16-1.26)*
Years since graduation (mean)			
21-30 y vs 0-20 y	0.91 (0.88-0.93)*	0.92 (0.91-0.94)*	0.87 (0.84-0.91)*
> 30 y v 0-20 y	0.86 (0.83-0.88)*	0.84 (0.83-0.86)*	0.83 (0.80-0.87)*
Organizational structure			
Family health group v FFS	0.90 (0.86-0.93)*	0.88 (0.85-0.90)*	0.89 (0.84-0.95)*
Family health network v FFS	1.09 (0.80-1.47)	1.26 (0.97-1.62)	0.85 (0.53-1.38)
Family health organization v FFS	0.88 (0.83-0.93)*	0.85 (0.81-0.88)*	0.79 (0.73-0.86)*
Family health team v FFS	0.95 (0.90-1.00)	0.88 (0.84-	0.80 (0.74-

		0.93)*	0.86)*
Other v FFS	0.87 (0.78-0.97)*	0.55 (0.52-0.59)*	0.82 (0.70-0.96)*
<u>Random Effects</u>			
Practice ^c	1.45 (1.43-1.47)*	1.57 (1.55-1.60)*	1.55 (1.52-1.59)*

Note: ;*p < .05; OR = odds ratio; CI = confidence interval; TTE = transthoracic echocardiogram; ECG = electrocardiogram; AHE = annual health examination; all reported values based on SAS PROC GLIMMIX output; model estimation method = RSPL; denominator degrees of freedom estimation method = between and within (bw); covariance structure = standard variance (vc).

a All odds ratios presented are adjusted for all other factors in the table.

b Indicates patient had an ECG on same day as an AHE.

c Median odds ratio reported with 95% CI in parentheses.

Appendix 2.5 Descriptive statistics for adverse clinical outcomes occurring with 12 months of index annual health examination (n = 3 629 859).

Clinical outcome	No. without ECG in 30 d (%) (n = 2 849 676)	No. with ECG in 30 d (%) (n = 780 183)
Death, n (%)	4 614 (0.16%)	<u>1 497 (0.19%)</u>
Cardiac-related hospitalization, n (%)	3 523 (0.12%)	<u>3 553 (0.46%)</u>
Revascularization, n (%)	1 066 (0.04%)	<u>1 538 (0.20%)</u>

Note: The proportion of deaths occurring due to cardiac-related reasons was not calculated, as cause of death data only available up to 2013.