The direct costs of overdiagnosed asthma in a longitudinal population-based study

Running title: Costs of overdiagnosed asthma

Bryan C. Ng[1]; Mohsen Sadatsafavi, MD, PhD[1,2]; Abdollah Safari, PhD[1,2]; J. Mark FitzGerald, MD[2]; Kate M. Johnson, MSc[1]

Affiliations:

[1] Respiratory Evaluation Sciences Program, Collaboration for Outcomes Research and Evaluation, Faculty of Pharmaceutical Sciences, University of British Columbia, Vancouver, Canada
[2] Institute for Heart and Lung Health, Department of Medicine, University of British Columbia, Vancouver, Canada

Corresponding Author: Kate M. Johnson
Faculty of Pharmaceutical Sciences, University of British Columbia, Vancouver Campus,
2405 Wesbrook Mall
Vancouver, BC Canada V6T 1Z3
Phone: 604-788-8575
Email: kate.johnson@alumni.ubc.ca

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1 **ABBREVIATIONS:**

2 BC: British Columbia

3 CI: Confidence Interval

4 FEV_1: Forced Expiratory Volume in 1 second

5 MPR: Medication Possession Ratio

6 SD: Standard Deviation

ABSTRACT

Objectives: A current diagnosis of asthma cannot be objectively confirmed in many patients with physician-diagnosed asthma. Estimates of resource use in overdiagnosed cases of asthma are necessary to measure the burden of overdiagnosis and evaluate strategies to reduce this burden. We assessed the difference in asthma-related healthcare resource use between patients with a confirmed asthma diagnosis and those with asthma ruled out.

Design: Population-based prospective cohort study.

Setting: Participants were recruited through random-digit dialling of both landlines and mobile phones in BC, Canada.

Participants: We included 345 individuals ≥12 years of age with a self-reported physician diagnosis of asthma which was confirmed by a bronchodilator reversibility or methacholine challenge test at the end of the 12-month follow-up.

Primary and secondary outcome measures: Self-reported annual asthma-related direct healthcare costs (2017 Canadian dollars), outpatient physician visits, and medication use from the Canadian healthcare system perspective.

Results: Asthma was ruled out in 86 (24.9%) participants. Average annual asthma-related direct healthcare costs for participants with confirmed asthma were $497.9 (SD $677.9), and $307.7 (SD $424.1) for participants with asthma ruled out. In the adjusted analyses, a confirmed diagnosis was associated with higher direct healthcare costs (Relative Ratio [RR]=1.60, 95%CI 1.14-2.22), increased rate of specialist visits (RR=2.41, 95%CI 1.05-5.40) and reliever medication use (RR=1.62, 95%CI 1.09-2.35), but not primary care physician visits (p=0.10) or controller medication use (p=0.11).

Conclusions: A quarter of individuals with a physician diagnosis of asthma did not have asthma

after objective re-evaluation. These participants still consumed a significant amount of asthma-related healthcare resources. The population-level economic burden of asthma overdiagnosis could be substantial.

Strengths and limitations of this study:

- Participants were recruited through random sampling of the general population in the province of British Columbia.
- Asthma diagnosis was confirmed or ruled out using sequential guideline-recommended objective airway tests.
- Healthcare resource use was self-reported, potential recall bias may have led to reduced accuracy.
- The study was unable to evaluate the indirect costs of overdiagnosis or the cost-savings from correcting the diagnosis.
- The generalizability of the results may be limited by regional differences in medical costs and practices.

Keywords: Asthma, Costs, Misdiagnosis, Observational Studies, Overdiagnosis

INTRODUCTION

Over 300 million people worldwide have been diagnosed with asthma.[1] Patients with asthma experience symptoms of wheezing, shortness of breath, chest tightness, and cough.[2] These symptoms, and periods of intensified disease activity referred to as exacerbations, impose a significant burden on healthcare resources and reduce patient quality of life.[3] A Canadian study estimated the excess direct medical costs of asthma at $1,058 (2013 Canadian dollars) per person-year.[4] The majority (74%) of asthma-attributed costs were due to medication use.[4]

Multiple evidence-based guidelines recommend confirming a diagnosis of asthma with objective testing for reversible airflow limitation or increased airway hyper responsiveness.[2,5] Despite these recommendations, previous studies suggest that in the community, asthma is diagnosed solely based on symptom history in over half of the cases.[6,7] The underuse of spirometry has been documented in Canada,[8] the United States,[9] and Europe.[10] A recent population-based study found that one in three patients with physician-diagnosed asthma did not meet the guideline-recommended spirometric criteria for asthma diagnosis and could have their medications safely stopped.[11] We refer to this group of patients as 'overdiagnosed'.[12] These overdiagnosed patients are likely to be imposing costs on the healthcare system due to treatment for a condition that does not exist, and may be experiencing symptoms of an underlying illnesses that is not being treated.[11] By some estimates, there are over 785,000 overdiagnosed asthma patients in Canada alone.[13]

In response to these findings, some authors have called for population-based screening or case finding to re-evaluate previous diagnoses of asthma.[11,13] Assessing the value of these

70 programs requires precise estimates of the burden of overdiagnosed asthma. To the best of our
71 knowledge, estimates of the cost differences between overdiagnosed and confirmed cases of
72 asthma currently do not exist. A previous study of the costs of overdiagnosed asthma was limited
73 to assessing the potential asthma-related cost savings that a secondary screening program could
74 provide.[13] Characterizing the patterns of healthcare resource use among patients in whom
75 asthma can be ruled out can help identify opportunities for re-evaluation and inform initiatives to
76 improve asthma diagnosis in the community.
77
78 We used a longitudinal population-based cohort of individuals with physician-diagnosed asthma
79 to address this important evidence gap. Our primary objective was to compare total direct
80 asthma-related healthcare costs in patients with a confirmed diagnosis of asthma versus patients
81 in whom a diagnosis of asthma was ruled out using objective testing. Our secondary objectives
82 were to characterize differences in healthcare resource use in terms of the 1) number of
83 outpatient physician visits, and the 2) type and amount of asthma medication use.
84
85
86 **METHODS**
87 **Study Design and Sample**
88 We used longitudinal data from the Economic Burden of Asthma study (University of British
89 Columbia Human Ethics #H10-01542), which has been previously described.[14,15] In
90 summary, individuals with a self-reported physician diagnosis of asthma and at least one asthma-
91 related healthcare encounter in the past 5 years were eligible. Participants were recruited through
92 random-digit dialling of both landlines and mobile phones in the census subdivisions of

93 Vancouver and Central Okanagan (populations of 603,502 and 179,839 in 2011, respectively) of
94 BC, Canada.[16] Between 2010 and 2012, 618 participants were recruited, evaluated at baseline,
95 and followed for 12 months with visits at 3-month intervals. We included 345 participants who
96 were ≥12 years of age at baseline and successfully completed a bronchodilator reversibility or
97 methacholine challenge test at the end of follow-up.
98
99 **Outcomes**
100 Participants reported their asthma-related primary care and specialist physician visits,
101 hospitalizations, emergency department visits, and current medication use at each study visit
102 with a recall period of 3 months. The primary outcome was total asthma-related direct healthcare
103 costs per patient over the one-year follow-up period. Total direct healthcare costs were
104 comprised of all outpatient and inpatient encounters, and medication costs incurred by the
105 patient. Cost categories were described by calculating the percentage of total average cost
106 constituted by each category. The methods used for calculating costs are detailed
107 elsewhere.[17,18] Briefly, costs for each patient were determined by multiplying self-reported
108 resource use quantities by unit cost of each resource. We determined the average unit cost of an
109 asthma-related physician visit (specialist vs. primary care) and hospitalization for the years 2008-
110 2012 using International Classification of Diseases codes from provincial healthcare
111 administrative data.[18] Medication unit costs were determined by linking Drug Identification
112 Numbers of participant-reported asthma medications to the Provincial Drug Master Plan
113 database.[19] Cost per dose was estimated using the lowest price equivalent of the medication.
114 All costs were adjusted to 2017 Canadian Dollars[20] and the analysis was conducted from the
115 perspective of the Canadian healthcare system.

116

117 Secondary outcomes were the number of asthma-related outpatient physician visits and use of
118 asthma medications. We did not evaluate asthma-related emergency department visits or
119 hospitalizations as a separate outcome due to the low frequency of these events (N=14). The
120 number of outpatient physician visits over one-year of follow-up was assessed separately by
121 physician type (primary care or specialist). Medication use was captured using the questionnaire
122 shown in *Figure E1*, and medications were classified into controller or reliever using a reference
123 list (*Table E1*). In general, controller medications are those with anti-inflammatory effects
124 (namely inhaled corticosteroids and leukotriene receptor antagonists), while reliever medications
125 are those that are used on as-needed basis for temporary symptom relief (namely short-acting
126 beta agonists). Medication use was determined by calculating the Medication Possession Ratio
127 (MPR) separately for controller and reliever medications. MPR represents the proportion of days
128 in which medications were available to the participant over the follow-up period.[21]

129

130 **Exposure: Objective confirmation of asthma**

131 Participants underwent an objective assessment of asthma at the final visit. The diagnostic
132 algorithm for asthma is shown in *Figure 1* and consisted of both bronchodilator reversibility and
133 methacholine challenge tests implemented in a stepwise fashion. Spirometry was performed by a
134 trained technician using a regularly calibrated spirometer. Reversible airflow obstruction was
135 defined as a ≥12% increase in Forced Expiratory Volume in 1 second (FEV_1) 15 minutes after
136 administration of 200mcg of salbutamol via pressurized metered dose inhaler and a spacer
137 device.[22] Participants who did not meet the criteria for reversible airflow obstruction returned
138 within one week to undergo a methacholine challenge test. Participants who did not meet the

139 criteria for asthma diagnosis at the first methacholine challenge test had their controller
140 medications tapered and discontinued by a respirologist before returning for a second
141 methacholine challenge test. A diagnosis of asthma was ruled out if FEV_1 decreased by <20%
142 following the administration of 16mg/mL of methacholine[23] in both methacholine challenge
143 tests. Participants had a 'confirmed asthma diagnosis' if they met the criteria for asthma at the
144 bronchodilator reversibility test or either methacholine challenge test.
145
146 <<Figure 1>>
147
148 **Statistical Analysis**
149 All statistical analyses were performed in R version 3.5.0.[24] We considered a two-tailed p-
150 value of <0.05 as statistically significant.
151
152 We constructed separate generalized linear regression models (negative binomial distribution,
153 log link) for the primary and secondary outcomes. This resulted in five separate models for the
154 following outcomes: annual asthma-related (1) direct healthcare costs, (2) number of primary
155 care physician visits, (3) number of specialist physician visits, (4) controller MPR, and (5)
156 reliever MPR. All models included the objective diagnosis of asthma (confirmed vs. ruled out) as
157 the exposure. Costs and MPR values (as a percentage) were rounded to the nearest integer value.
158 Models were adjusted for participant tobacco smoking history (ever smoked vs. never smoked),
159 ethnicity (Caucasian vs. non-Caucasian), age, sex, education (postsecondary vs. no), income
160 (annual household income ≥$70,000 vs. less), and third-party insurance coverage for medications
161 (coverage vs. no), all self-reported at baseline with a 12-month recall period. The resulting

162 regression coefficients were exponentiated to create effect estimates on the relative scale (rate
163 ratio [RR]). Asthma severity was not adjusted for due to the high likelihood that there is a causal
164 relationship between severe asthma and a confirmed diagnosis of asthma.[11]
165
166
167 **RESULTS**
168 **Sample Characteristics**
169 The cohort selection procedure is illustrated in *Figure 2*. From the Economic Burden of Asthma
170 cohort (618 participants), we excluded 86 participants who were <12 years of age, 153 in whom
171 a methacholine challenge was contraindicated (N=29), refused (N=112), or could not be
172 completed for other reasons (N=14), and 34 participants who were lost to follow-up. The final
173 study cohort included 345 participants who underwent an objective diagnostic test for asthma at
174 the final visit (12 months after baseline). Their characteristics are shown in *Table 1*. 212 (61.4%)
175 participants were female, and the mean age at baseline was 48.9 (standard deviation [SD] 17.8)
176 years. A diagnosis of asthma was confirmed in 259 (75.1%) participants: 138 (53.3%) by
177 bronchodilator reversibility test, 98 (37.8%) following the first methacholine challenge test, and
178 23 (8.9%) following the second methacholine challenge test. Asthma was ruled out in 86
179 (24.9%) participants following negative results on all bronchodilator reversibility and
180 methacholine challenge tests.
181
182 <<Figure 2>>
183
184 **Table 1.** Sample characteristics

Characteristic	Total (n = 345)	Asthma confirmed (n = 259)	Asthma ruled out (n = 86)	*p*-value[§]
Variables evaluated at baseline				
Female, n (%)	212 (61.4)	156 (60.2)	56 (65.1)	0.50
Age, mean (SD)	48.9 (17.8)	49.3 (18.1)	47.7 (17.2)	0.46
Ever smoked (vs. never smoked), n (%)	93 (27.0)	71 (27.4)	22 (25.6)	0.85
Caucasian (vs. non-Caucasian), n (%)	267 (77.4)	206 (79.5)	61 (70.9)	0.13
High income (vs. low income) [†], n (%)	183 (53.0)	137 (52.9)	46 (53.5)	>0.99
Health insurance (full coverage vs. not full coverage) [‡], n (%)	69 (20.0)	52 (20.1)	17 (19.8)	>0.99
Higher education (postsecondary vs. no postsecondary), n (%)	242 (70.1)	178 (68.7)	64 (74.4)	0.39
Variables evaluated during follow-up				
Total direct healthcare costs, mean (SD)	$450.5 ($629.2)	$497.9 ($677.9)	$307.7 ($424.1)	<0.01[*]
Primary care physician visits, mean (SD)	2.2 (4.1)	2.1 (2.8)	2.7 (6.6)	0.85
Specialist physician visits, mean (SD)	0.5 (1.9)	0.6 (2.2)	0.2 (0.8)	0.02[*]
MPR of controller medications, mean (SD)	69.7% (74.4)	74.9% (76.4)	54.0% (65.8)	0.02[*]
MPR of reliever medications, mean (SD)	28.4% (33.2)	31.3% (34.3)	19.5% (28.0)	<0.01[*]

MPR: Medication Possession Ratio

[*] Significant at 0.05 level

[†] High income defined as household income ≥ $70,000

[‡] Full coverage defined as all drug and physician services paid for through third-party coverage

[§] p-values for the absolute difference between the 'asthma confirmed' and 'asthma ruled out' groups were determined using a Student t-test for continuous variables and Chi-squared test for categorical variables

185

186

187 **Total Direct Healthcare Costs**

188 Average annual direct healthcare costs over one year was $497.9 (SD $677.9) in participants
189 with confirmed asthma, and $307.7 (SD $424.1) in those with asthma ruled out. There was a
190 significant difference in average annual direct healthcare costs ($190.2) between exposure
191 groups in the unadjusted analysis (p<0.01, *Table 1*). Average annual direct healthcare costs were
192 1.6 times (95%CI 1.14–2.22, p<0.01) higher in participants with confirmed asthma after
193 adjustment for participant smoking history, ethnicity, age, sex, education, income, and insurance
194 coverage (*Figure 3*). Medications comprised the greatest proportion of total costs in both
195 correctly diagnosed and overdiagnosed individuals (56.4% and 47.6%, respectively, *Table 2*).

196

197 <<Figure 3>>

198

199 **Table 2.** Asthma-related healthcare cost categories over one year of follow-up.

Cost Category	Cost per patient mean (SD)	Percentage of total cost per patient
	Asthma ruled out	
Medications	$146.39 ($239.94)	47.6%
Primary care physician visits	$118.24 ($292.64)	38.4%
Specialist physician visits	$27.87 ($101.37)	9.1%
Hospitalization	$0 ($0)	0.0%
Emergency visits	$15.23 ($69.07)	4.9%
TOTAL	$307.70 ($422.23)	100.0%
	Asthma confirmed	
Medications	$280.74 ($404.17)	56.4%
Primary care physician visits	$90.98 ($125.66)	18.3%
Specialist physician visits	$73.11($257.61)	14.7%
Hospitalization	$39.24 ($362.65)	7.9%
Emergency visits	$13.91 ($72.07)	2.8%
TOTAL	$497.90 ($676.89)	100.0%

200

201

202 **Outpatient Physician Visits**

203 The total number of annual primary care physician visits was similar between participants with
204 confirmed asthma and those with asthma ruled out (2.1 vs. 2.7 visits, p=0.85, *Table 1*). However,
205 participants with confirmed asthma visited specialist physicians more often than those who had
206 asthma ruled out (0.6 vs. 0.2 visits per year, p=0.02). The adjusted analysis also indicated no
207 significant difference in the number of primary care physician visits between participants with
208 confirmed asthma and those with asthma ruled out (p=0.10, *Figure 3*). Confirmed asthma was
209 associated with 2.41 times (95%CI 1.05–5.40, p=0.03) more specialist visits than when an
210 asthma diagnosis could be ruled out.

211

212 **Medication Usage**

213 Participants with a confirmed diagnosis of asthma used controller medications for a greater
214 proportion of follow-up time than those with asthma ruled out (MPR of 74.9% vs. 54.0%,
215 p=0.02), and similarly for reliever medications (31.3% vs. 19.5%, p<0.01, *Table 1*). This
216 difference persisted in the adjusted analysis for reliever medications but not for controller
217 medications (p=0.11, *Figure 3*). The MPR for reliever medications was 1.62 times higher
218 (95%CI 1.09–2.35, p=0.01) among participants with confirmed asthma than those with asthma
219 ruled out.

220

221

222 **DISCUSSION**

223 In this study, we used objective testing to confirm the diagnosis of asthma in a population-based
224 sample of patients with a self-reported physician diagnosis of asthma. We found that asthma
225 could be ruled out in 25% of cases after negative spirometry and two negative methacholine
226 challenge tests. This proportion is in line with the 28-33% rate of overdiagnosis reported in
227 previous Canadian studies.[11,13,25] We compared asthma-related direct healthcare costs
228 between participants with confirmed asthma versus those with asthma ruled out. Although total
229 direct costs were higher in participants with a confirmed diagnosis of asthma, the costs of
230 overdiagnosed asthma remained substantial. The average direct asthma-related healthcare costs
231 for a participant with overdiagnosed asthma was $308 over 12 months, which was $190 lower
232 than for participants with a confirmed diagnosis. This difference in costs remained statistically
233 significant after controlling for confounding variables that could affect both the exposure and
234 outcomes but are likely not on the causal pathway between them.

235

236 Participants with overdiagnosed asthma visited specialists less frequently than those with
237 confirmed asthma, but they visited primary care physicians as frequently. These participants may
238 have scheduled a similar number of annual primary care visits for routine monitoring of 'asthma'
239 activity or to fill new prescriptions. Conversely, participants with confirmed asthma may have
240 had exacerbations of their asthma symptoms that required referral to a specialist physician to
241 improve asthma control.[26] Across both groups, participants visited primary care physicians
242 more frequently than specialist physicians; 79% of our sample visited a primary care physician at
243 least once during follow-up. The high frequency of these visits, and their low cost compared to
244 specialist consultations,[13] suggests that primary care visits may provide effective opportunities

245 for re-evaluating previous asthma diagnoses.

246

247 On average, overdiagnosed participants possessed controller medications for over half of follow-
248 up time, and reliever medications for 20 percent of follow-up time. Reliever medications are
249 typically used as needed while controller medications are used daily.[2,5] In comparison to
250 participants with confirmed asthma, and after adjusting for potential confounders, participants
251 with asthma ruled out tended to use similar levels of controller medications and less reliever
252 medications. This difference may be due to a lower symptom burden in overdiagnosed
253 participants, which led to self-adjustment of reliever medication use.[27] Conversely,
254 overdiagnosed individuals may have used controller medications as prescribed.

255

256 Although inhaled medications for asthma are generally safe, the use of asthma medications
257 among overdiagnosed patients puts them at risk of net harm due to medication side effects.[28]
258 These patients are also incurring additional healthcare expenditure without therapeutic benefit.
259 Further, asthma medications may have masked symptoms of a serious underlying illness and
260 resulted in a delay in the diagnosis and treatment of the correct disease. We did not evaluate the
261 true underlying condition in this sample, but a similar study by Aaron et al.[11] found that two
262 out of 213 patients had subglottic stenosis, which was treated as asthma for a number of years
263 before the correct diagnosis was identified during the study. If other health conditions were
264 responsible for the overdiagnosis of asthma, their costs have implications for the burden of
265 overdiagnosed asthma. For example, if ruling out an asthma diagnosis results in the correct
266 alternative diagnosis, the proper management of the underlying condition could confer further
267 cost benefits.

268

269 To our knowledge, this is the first study to examine the costs associated with overdiagnosed
270 asthma. Our findings have important population-level implications. Given an estimate of
271 approximately 785,000 individuals with overdiagnosed asthma in Canada,[13] and an annual
272 direct healthcare cost of $308 per patient, the estimated cost of overdiagnosed asthma in Canada
273 is $242 million per year (2017 Canadian dollars). A previous study reported an average cost of
274 $263 per patient (2009 Canadian dollars) for additional physician visits to reassess an asthma
275 diagnosis. This resulted in an average lifetime cost savings of $351 per patient screened,[13]
276 primarily due to the avoided costs of asthma medications. Our results suggest that additional
277 screening to correct an overdiagnosis of asthma would save asthma-related costs in the first year,
278 with savings compounding in subsequent years. Savings could be reallocated to the management
279 of individuals with a true diagnosis of asthma, especially those with severe asthma who could
280 pursue novel but expensive treatments, or to identify and treat the underlying diseases of
281 overdiagnosed patients.[29] Given the prevalence and costs of overdiagnosis, our findings
282 highlight the need for routine objective testing to confirm all new and existing diagnoses of
283 asthma.[2,5]

284

285 There are several strengths to this study. We used a population-based random sample of patients
286 with a physician diagnosis of asthma, meaning our results are likely to be representative of
287 routine healthcare use in the general asthma population. We used longitudinal healthcare
288 utilization data, which compared to cross-sectional data, likely provides a less-biased estimate of
289 the average costs accrued by an individual. Finally, we evaluated airway reversibility using

290 objective testing following the recommendations of international guidelines.[2,5] This allowed
291 us to evaluate the costs of evidence-based best practices.
292
293 Our study has several limitations. We did not include indirect costs in our analysis, and we were
294 therefore unable to consider the societal costs of overdiagnosis. Previous studies suggest that the
295 cost of productivity loss in this sample is substantial.[15] Physician visits and medication use
296 were self-reported with a recall period of 3 months. It is possible that recall bias reduced the
297 accuracy of our measurements. Our algorithm for ruling out asthma involved one less
298 methacholine challenge test than in some previous studies,[11,13,30] which makes it slightly less
299 rigorous. It is possible that this led to a higher rate of overdiagnosis in our study, however, over
300 90% of diagnoses were confirmed by the second visit in previous studies.[13,25] We excluded
301 participants in whom an objective diagnostic test was contraindicated due to asthma-related
302 reasons, which may have resulted in lower representation of participants with more severe
303 disease and therefore higher resource utilization. Finally, we only assessed asthma-related costs;
304 we were unable to determine the costs of the true underlying condition or the benefit of
305 correcting the diagnosis.
306
307
308 **CONCLUSIONS**
309 In this population-based sample, one in four participants with a physician diagnosis of asthma
310 had their diagnosis ruled out upon objective airflow reversibility testing. Patients with
311 overdiagnosed asthma consumed a substantial amount of asthma-related healthcare resources,
312 although less than those with confirmed asthma. The extent of overdiagnosed asthma in Canada

313 and other countries, and its associated healthcare resource costs, suggests that the population-
314 level burden of overdiagnosed asthma is high. Future studies should evaluate the cost-
315 effectiveness of systematic screening or case detection initiatives for re-evaluating previous
316 diagnoses of asthma.
317
318
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322 performed all data analyses and wrote the first draft of the manuscript. AS and KMJ provided
323 guidance on the statistical analysis. All authors critically commented on the manuscript and
324 approved the final version. KMJ is the guarantor of the manuscript.
325
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412

FIGURE LEGENDS

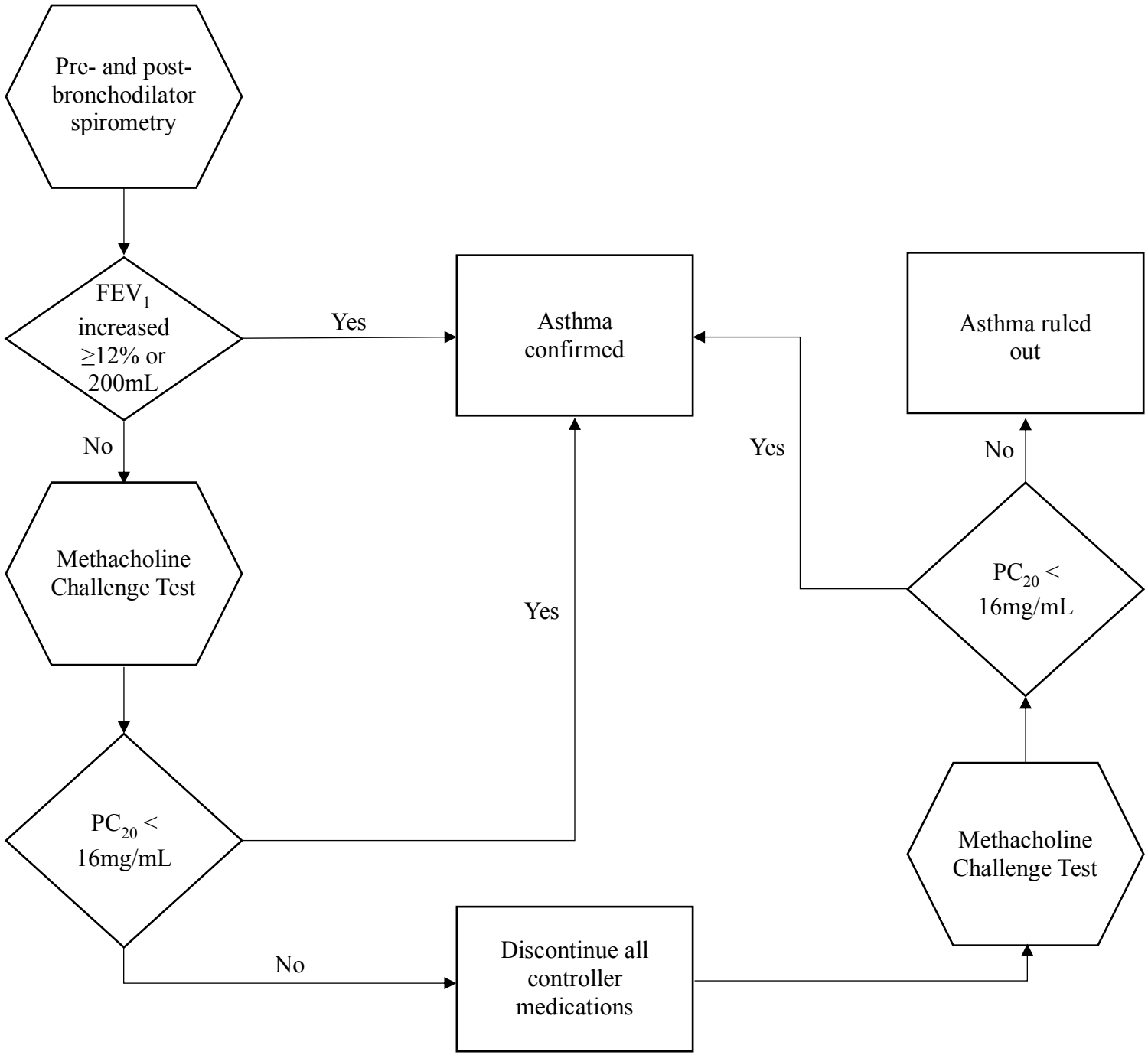
Figure 1. Algorithm for confirming or ruling out a diagnosis of asthma.

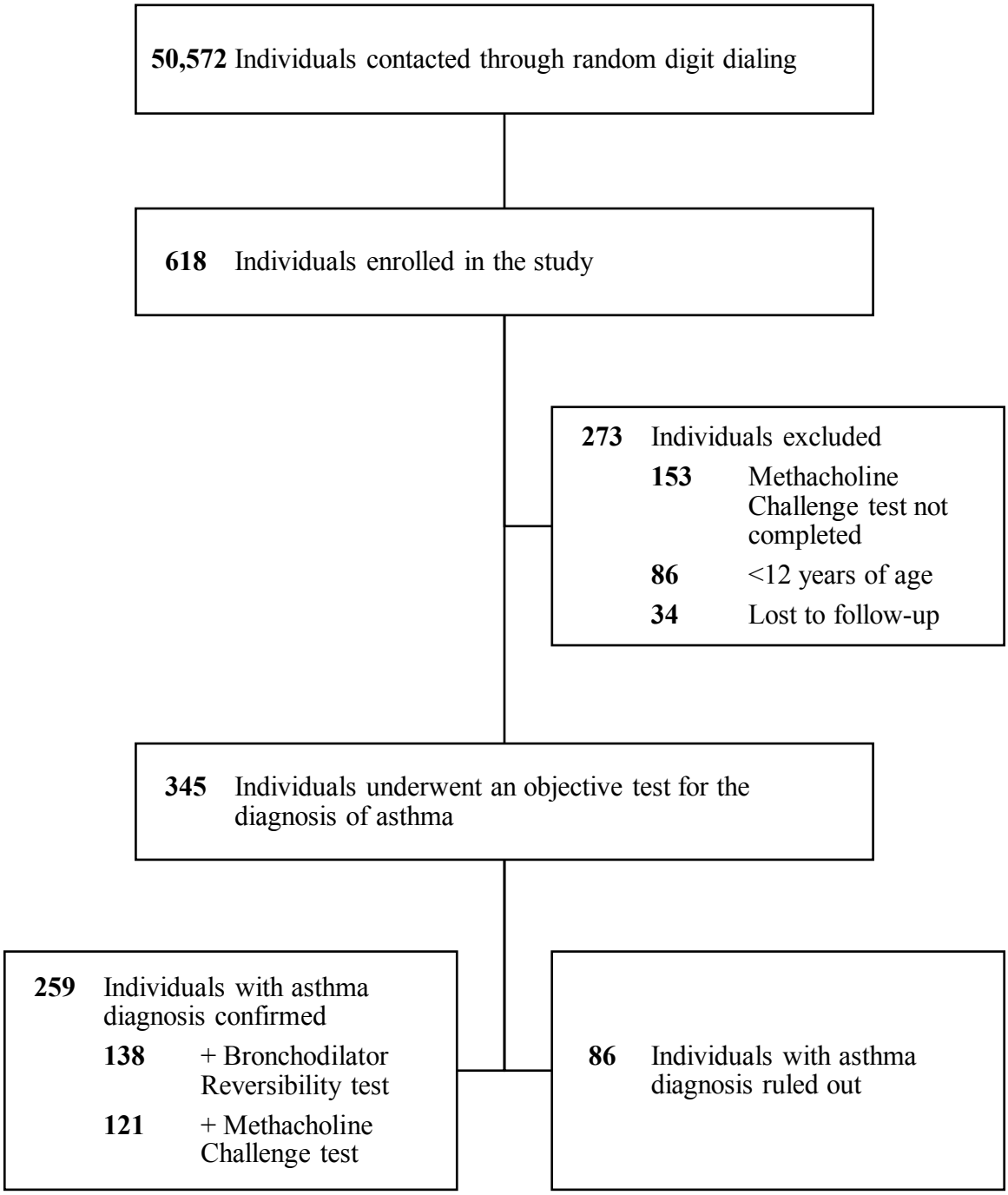
FEV_1; Forced Expiratory Volume in 1 second, PC_{20}; Provocative concentration of methacholine needed to produce a 20% fall in FEV_1 from baseline

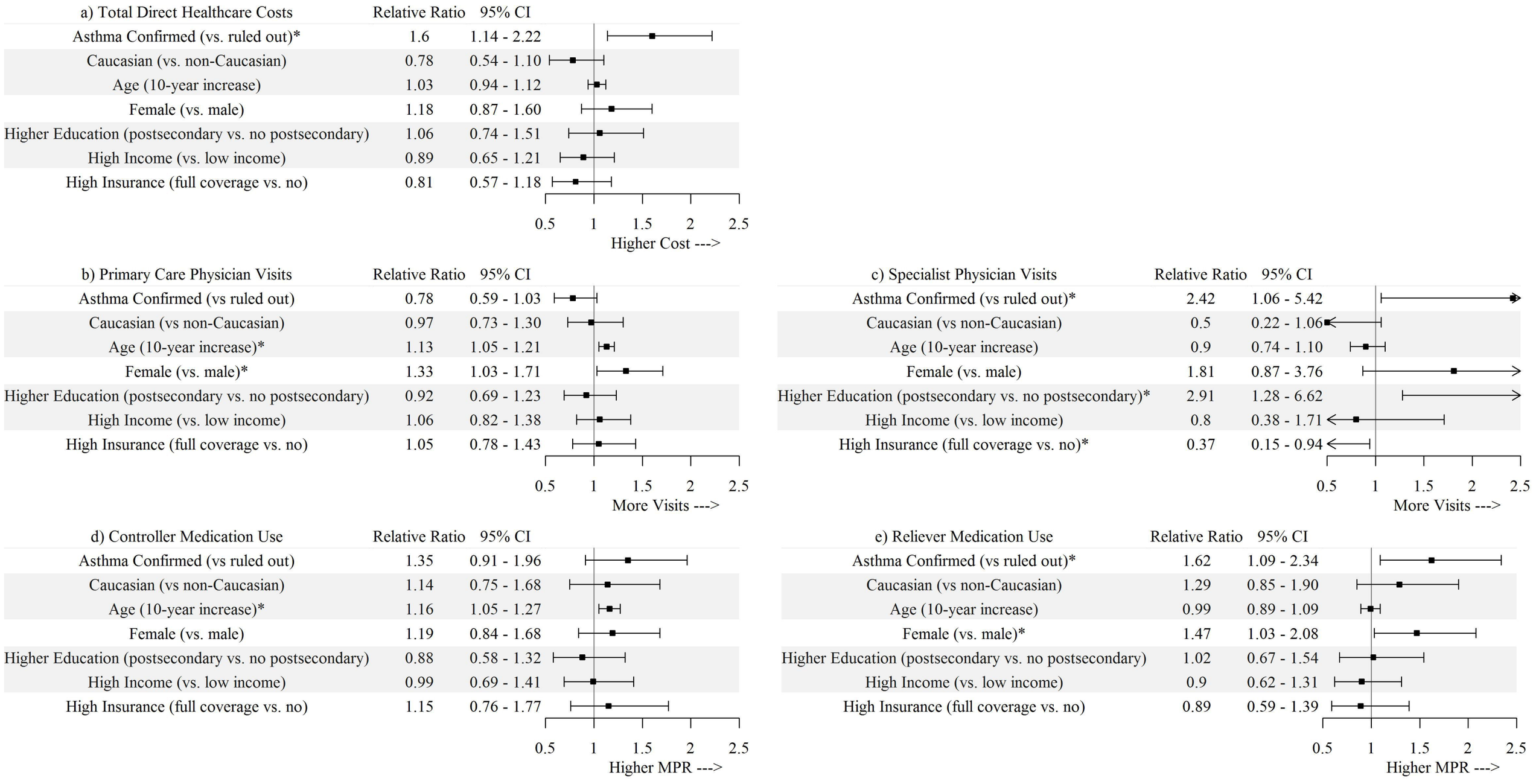
Figure 2. Sample selection procedure.

Figure 3. Relative Ratios for the adjusted differences in asthma-related a) total direct healthcare costs, b) primary care physician visits, c) specialist physician visits, d) controller medication use, and e) reliever medication use over one year of follow-up between patients with confirmed asthma and those with asthma ruled out.

* Significant at 0.05 level


Pre- and post-bronchodilator spirometry
FEV1 increased ≥12% or 200mL
Yes
Asthma confirmed
No
Methacholine Challenge Test
PC20 < 16mg/mL
Yes
No
Discontinue all controller medications
Methacholine Challenge Test
PC20 < 16mg/mL
Yes
No
Asthma ruled out


50,572 Individuals contacted through random digit dialing
618 Individuals enrolled in the study
273 Individuals excluded
153 Methacholine Challenge test not completed
86 <12 years of age
34 Lost to follow-up
345 Individuals underwent an objective test for the diagnosis of asthma
259 Individuals with asthma diagnosis confirmed
138 + Bronchodilator Reversibility test
121 + Methacholine Challenge test
86 Individuals with asthma diagnosis ruled out


a) Total Direct Healthcare Costs
Relative Ratio
95% CI
Asthma Confirmed (vs. ruled out)* 1.6 1.14 - 2.22
Caucasian (vs. non-Caucasian) 0.78 0.54 - 1.10
Age (10-year increase) 1.03 0.94 - 1.12
Female (vs. male) 1.18 0.87 - 1.60
Higher Education (postsecondary vs. no postsecondary) 1.06 0.74 - 1.51
High Income (vs. low income) 0.89 0.65 - 1.21
High Insurance (full coverage vs. no) 0.81 0.57 - 1.18
0.5 1 1.5 2 2.5
Higher Cost --->
b) Primary Care Physician Visits
Relative Ratio
95% CI
Asthma Confirmed (vs ruled out) 0.78 0.59 - 1.03
Caucasian (vs non-Caucasian) 0.97 0.73 - 1.30
Age (10-year increase)* 1.13 1.05 - 1.21
Female (vs. male)* 1.33 1.03 - 1.71
Higher Education (postsecondary vs. no postsecondary) 0.92 0.69 - 1.23
High Income (vs. low income) 1.06 0.82 - 1.38
High Insurance (full coverage vs. no) 1.05 0.78 - 1.43
0.5 1 1.5 2 2.5
More Visits --->
c) Specialist Physician Visits
Relative Ratio
95% CI
Asthma Confirmed (vs ruled out)* 2.42 1.06 - 5.42
Caucasian (vs non-Caucasian) 0.5 0.22 - 1.06
Age (10-year increase) 0.9 0.74 - 1.10
Female (vs. male) 1.81 0.87 - 3.76
Higher Education (postsecondary vs. no postsecondary)* 2.91 1.28 - 6.62
High Income (vs. low income) 0.8 0.38 - 1.71
High Insurance (full coverage vs. no)* 0.37 0.15 - 0.94
0.5 1 1.5 2 2.5
More Visits --->
d) Controller Medication Use
Relative Ratio
95% CI
Asthma Confirmed (vs ruled out) 1.35 0.91 - 1.96
Caucasian (vs non-Caucasian) 1.14 0.75 - 1.68
Age (10-year increase)* 1.16 1.05 - 1.27
Female (vs. male) 1.19 0.84 - 1.68
Higher Education (postsecondary vs. no postsecondary) 0.88 0.58 - 1.32
High Income (vs. low income) 0.99 0.69 - 1.41
High Insurance (full coverage vs. no) 1.15 0.76 - 1.77
0.5 1 1.5 2 2.5
Higher MPR --->
e) Reliever Medication Use
Relative Ratio
95% CI
Asthma Confirmed (vs ruled out)* 1.62 1.09 - 2.34
Caucasian (vs non-Caucasian) 1.29 0.85 - 1.90
Age (10-year increase) 0.99 0.89 - 1.09
Female (vs. male)* 1.47 1.03 - 2.08
Higher Education (postsecondary vs. no postsecondary) 1.02 0.67 - 1.54
High Income (vs. low income) 0.9 0.62 - 1.31
High Insurance (full coverage vs. no) 0.89 0.59 - 1.39
0.5 1 1.5 2 2.5
Higher MPR --->