Do community demographics, environmental characteristics and access to care affect risks of developing ACOS and mortality in people with asthma?

To the Editor:

Individuals with asthma and chronic obstructive pulmonary disease (COPD) overlap syndrome (ACOS) have a more rapid decline in lung function, more frequent exacerbations and worse quality of life than those with asthma or COPD alone [1–3]. Various risk factors may be associated with the development of ACOS, such as smoking history and status, obesity, comorbidity and indoor and outdoor environmental exposures [1, 4–6]. The risk of developing ACOS may vary substantially by region, since demographic and environmental risk factors and community characteristics are not geographically homogeneous. Here, we use population-based data to estimate the incidence of ACOS in the asthma population and to measure the association between demographic factors, community-level characteristics and environmental factors and the risk of incident ACOS and all-cause mortality while accounting for spatial autocorrelation.

A cohort approach was used to follow individuals with incident asthma in Ontario, Canada aged ⩾18 years in 1996, to determine the incidence of COPD (*i.e.* ACOS). While individuals with ACOS may consist of various phenotypes [1, 7, 8], in this paper, our focus is on those with physician-diagnosed asthma who subsequently received a physician diagnosis of COPD. Using validated asthma and COPD health administrative case definitions [9, 10] and linking individual level data across multiple provincial health administrative databases (hospital discharges, emergency department visits, physician claims and death certificates), we identified incident asthma in 1996–2009, incident COPD in 1998–2014 and all-cause mortality in 1996–2014. In order to examine geographical variations in outcomes and risk factors, we applied an ecological design using data at the Census Division (CD) level. In Ontario, there are 49 CDs that vary in size (663–439 000 km^2) and population density (0.1–4150 people per km^2).

To distinguish between incident and prevalent cases, a minimum 5-year asthma- or COPD-free observation period prior to the incidence date was applied. Those without a valid health card number for data linkage, missing residence postal code, age at COPD diagnosis <35 years or with COPD diagnosis prior to asthma were excluded. To minimise potential false positives (*i.e.* an initial asthma diagnosis that was later changed to COPD), those with COPD diagnosed ⩽2 years after asthma incidence were excluded (n=26 591, 6% of asthma population).

The following risk factors were calculated at the CD level: 1) the Ontario Marginalization Index (ON-Marg), a proxy measure of socioeconomic status (SES) measured using four dimensions: material deprivation, residential instability, ethnic concentration and dependency [11]; 2) smoking prevalence rates derived from the 2013 Canadian Community Health Survey; 3) the Air Quality Health Index (AQHI), a composite air pollution index based on levels of ozone (O_3), fine particles with a diameter of 2.5 µm or less ($PM_{2.5}$) and nitrogen dioxide (NO_2) [12], measured from 49 fixed-site monitors around the province; and 4) density of and travel times calculated along a driving network to respiratory healthcare professionals (respiratory therapists and respirologists) and pulmonary function laboratories.

Poisson regression models were fitted to the data to measure the association between the risk factors described above and observed counts of incident ACOS and all-cause mortality. The log of the expected counts of the outcome, calculated based on provincial age- and sex-specific rates, were used as an offset. A

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stochastic spatial random effect term was added to account for spatial autocorrelation. The R package CARBayes was used to calculate adjusted risk ratios (RR) and Bayesian 95% credible regions (CR) [13].

Of the 414 568 Ontarians with incident physician-diagnosed asthma included in the study, 32 867 (7.9%) were diagnosed with incident COPD, and 39 022 (9.4%) died. Among those who developed COPD, the median time from asthma incidence to COPD was 6.2 years (interquartile range (IQR) 3.8–9.4). Among those who died, the median time from asthma incidence to death was 7.8 years (IQR 4.9–11.1). The median yearly average AQHI was 3.3, corresponding to a low health risk. The median community-level prevalence of current smoking was 21.3%. The density of respiratory therapists was relatively high (15.3 per 100 000 population) compared to that of respirologists (0.74 per 100 000 population) and pulmonary function laboratories (0.67 per 100 000 population). Median travel times to respiratory healthcare professionals and pulmonary function laboratories were all under 30 min.

Table 1 contains Bayesian risk estimates for the incidence of ACOS and mortality (adjusted for covariates and both unadjusted and adjusted for spatial autocorrelation).

After adjusting for covariates and spatial autocorrelation, those living in more materially deprived areas had a 46% higher risk of incident ACOS (RR 1.46, 95% CR 1.13, 1.95) and a 28% higher risk of mortality (RR 1.28, 95% CR 1.12, 1.46). Those living in areas with a higher ethnic concentration had a reduced risk of incident ACOS (RR 0.72, 95% CR 0.58, 0.87) and mortality (RR 0.82, 95% CR 0.75, 0.90). Our data suggested that increased AQHI was associated with an increased risk of incident ACOS (RR 1.44, 95% CR 0.91, 2.18) and mortality (RR 1.24, 95% CR 1.00, 1.50), but these associations were not significant. There were no significant associations between the outcomes and residential instability, dependency, community-level smoking prevalence or access to respiratory healthcare professionals or pulmonary function laboratories.

Our finding of material deprivation being associated with a higher risk of incident ACOS and mortality is consistent with findings of low SES being associated with higher respiratory diseases morbidity [14]. Despite universal healthcare, individuals may still have a financial barrier to chronic disease management (*e.g.* cost of prescription medications, which are not routinely covered in Ontario).

Areas with a higher ethnic concentration had a lower risk of mortality and incident ACOS. Omariba [15] found that Canadian immigrants have lower avoidable mortality than non-immigrants and suggested that differential access to and use of health services, differences in protective health-related behaviour, and the

TABLE 1 Unadjusted and adjusted Bayesian spatial model risk estimates and their respective 95% credible regions (CRs)

Covariates	**Incidence of ACOS**				**All-cause mortality**			
	Unadjusted for spatial autocorrelation		**Adjusted for spatial autocorrelation**		**Unadjusted for spatial autocorrelation**		**Adjusted for spatial autocorrelation**	
	RR	**95% CR**	**RR**	**95% CR**	**RR**	**95% CR**	**RR**	**95% CR**
Measures of marginalisation								
Material deprivation	**1.62**	**(1.25, 2.05)**	**1.46**	**(1.13, 1.95)**	**1.34**	**(1.18, 1.50)**	**1.28**	**(1.12, 1.46)**
Residential instability	1.07	(0.80, 1.44)	1.10	(0.80, 1.52)	1.15	(0.97, 1.40)	1.09	(0.94, 1.28)
Ethnic concentration	**0.73**	**(0.63, 0.84)**	**0.72**	**(0.58, 0.87)**	**0.87**	**(0.81, 0.95)**	**0.82**	**(0.75, 0.90)**
Dependency	**1.45**	**(1.17, 1.78)**	0.88	(0.69, 1.11)	**1.23**	**(1.08, 1.37)**	0.92	(0.79, 1.07)
Neighbourhood smoking prevalence %	**1.03**	**(1.02, 1.05)**	1.00	(0.98, 1.02)	**1.02**	**(1.01, 1.03)**	1.00	(0.99, 1.01)
Air Quality Health Index	0.72	(0.37, 1.40)	1.44	(0.91, 2.18)	0.88	(0.62, 1.24)	**1.24**	**(1.00, 1.50)**
Time travelled to (log transformed)								
Pulmonary function laboratory	0.94	(0.77, 1.08)	1.00	(0.89, 1.13)	1.00	(0.92, 1.10)	0.99	(0.93, 1.05)
Respiratory therapist	1.04	(0.93, 1.19)	1.04	(0.96, 1.12)	1.02	(0.94, 1.10)	1.01	(0.97, 1.07)
Respirologist	1.08	(0.96, 1.23)	0.98	(0.89, 1.08)	1.01	(0.94, 1.09)	0.99	(0.95, 1.04)
Density (per 100 000 population)								
Pulmonary function laboratory	1.05	(0.98, 1.10)	1.02	(0.97, 1.08)	1.01	(0.97, 1.05)	0.99	(0.96, 1.02)
Respiratory therapist	1.00	(0.99, 1.01)	1.00	(0.99, 1.01)	1.00	(0.99, 1.01)	1.00	(0.99, 1.00)
Respirologist	0.94	(0.89, 1.00)	0.96	(0.92, 1.00)	0.98	(0.95, 1.02)	1.00	(0.98, 1.02)
Spatial variation (τ^2)			0.02	(0.01, 0.06)			0.00	(0.00, 0.02)
Spatial autocorrelation (ρ)			0.40	(0.03, 0.89)			0.52	(0.06, 0.93)
Device information criterion			472.45				460.60	

Bold values represent risk estimates and 95% credible regions that do not include 1.00.

"healthy immigrant effect" may play a role. Similarly, lower rates of ACOS in areas with higher ethnic concentration may be attributable to the healthy immigrant effect or underuse of healthcare services.

Some limitations of this study should be noted. Individual-level data on comorbidity, lifestyle factors, health-seeking behaviour, availability of a drug plan and adherence to prescribed medication were not available, which limits our ability to draw definitive conclusions concerning factors that drive individual-level risks of incident ACOS and mortality. Community-level smoking was used as a proxy to measure tobacco exposure, which may obscure the effect of individual smoking on the outcomes of interest. Access to smoking cessation programmes and Certified Respiratory Educators (who may be respiratory therapists, nurses or pharmacists) trained to provide chronic disease management are important unmeasured access to care factors.

In summary, community-level smoking prevalence and access to respiratory healthcare professionals and pulmonary function labs had little, if any, effect on incident ACOS and all-cause mortality in the asthma population. Our results suggested that air pollution may be associated with an increased risk of all-cause mortality. Material deprivation was the only risk factor that was associated with both increased incident ACOS and all-cause mortality, suggesting that factors outside of the universal healthcare system may play an important role in health outcomes of marginalised populations. Focusing on barriers faced by marginalised population, such as improving sub-standard housing conditions and increasing awareness of health effects of air pollution, may be more effective strategies to improving health outcomes for asthma patients at risk of ACOS and mortality.

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