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## Risk factors for hospitalization, intensive care, and mortality among patients with asthma and COVID-19

*To the Editor:*

Respiratory viral illnesses are a well-established trigger of asthma exacerbations in children and adults[1] and risk factor for poor outcomes and high health care utilization.[2] Early studies from China identified chronic pulmonary disease as a risk factor[3] for novel coronavirus disease 2019 (COVID-19) severity[4] and death.[5] US-based studies report that approximately 7% to 9% of hospitalized patients with COVID-19 had chronic lung disease,[6,7] with asthma more prevalent than chronic obstructive pulmonary disease (COPD) (9% vs 5.4%, respectively).[7] Recent analyses of COVID-19 cohorts suggest that chronic respiratory disease may unexpectedly be less of a risk factor for COVID-19 infection and severity than nonrespiratory diseases.[8] However, most studies to date do not distinguish asthma from COPD within chronic respiratory disease, limiting identification of asthma-specific risk factors.[9]

This case series used data (March 3, 2020, to June 8, 2020) from the Massachusetts-based Mass General Brigham (MGB, formerly Partners HealthCare) health system's electronic health record. Inclusion criteria were (1) COVID-19 positive based on nasopharyngeal or sputum severe acute respiratory syndrome coronavirus 2 RT-PCR test administered between March 3, 2020, and May 20, 2020; (2) age 18 years or more at COVID-19 diagnosis; (3) previously diagnosed asthma, assessed as active asthma diagnosis on problem list or 2 or more separate encounters with *International Classification of Diseases*, *Ninth Revision* and/or *International Classification of Diseases*, *Tenth Revision* codes (detailed in Table E1 in this article's Online Repository at www.jacionline.org) as a primary or secondary diagnosis; and (4) MGB primary care provider. Data on demographic characteristics, socioeconomic markers, baseline body mass index, insurance, smoking status, baseline outpatient-prescribed asthma medications, comorbidities including allergic and respiratory diseases, and clinical course of COVID-19 care were extracted. Patients' encounter history was followed for 14 days from COVID-19 diagnosis for hospitalization and intensive care unit (ICU) admission, or by June 8, 2020, for mortality.

We examined associations of demographic and clinical characteristics with hospitalization and ICU admission among those hospitalized for COVID-19, and mortality. Groups were compared using the Mann-Whitney-Wilcoxon test for continuous variables and the chi-square test or Fisher exact test for categorical variables. Unadjusted $P$ value less than or equal to .1 was used as a cutoff for choosing variables to enter into subsequent risk factor analysis. We performed univariable and multivariable analysis using age-stratified logistic regression. Statistical significance was accepted at a 2-sided $P$ value of less than or equal to .05. A Bonferroni-corrected $P$ value of less than .0016 was used to adjust for multiple testing. Statistical analyses were performed in R software, version 3.5.3 (R Foundation for Statistical Computing).

A total of 1827 patients met inclusion criteria (Table I). The median age was 54 years (interquartile range, 37-66 years), and 1232 (67.4%) were female. More than two-thirds of patients were triaged to outpatient care; 565 patients (30.9%) were hospitalized, and of those, less than half (n = 236 [41.8%]) were admitted to the ICU. Almost all hospitalized patients were admitted to inpatient (99.3%) or ICU (97.9%) services within 14 days of COVID-19 diagnosis. The mortality rate among patients with asthma was 5.4% (n = 98) across all patients (outpatient and hospitalized), 15.6% for hospitalized patients, and 23.3% for ICU patients, with 70 (71.4%) patients dying within 14 days of COVID-19 diagnosis (see Table E2 in this article's Online Repository at www.jacionline.org). Twenty-three (4.1%) hospitalized patients remained hospitalized at the time of study censoring. Mortality rate for all adult MGB COVID-19–positive patients during this same time period was 4.5% overall, 15.7% for hospitalized, and 23.5% for ICU patients.

Compared with the outpatient group, hospitalized patients had higher baseline use of inhaled-corticosteroid (ICS)-long-acting-beta-agonist combination and anticholinergic controller medications. Controller medication use did not differ in the hospitalized general inpatient versus ICU groups. More patients in the outpatient group had only a short-acting beta-agonist (SABA) prescribed in the previous year compared with hospitalized patients ($P < .001$), whereas a higher percentage of hospitalized patients had been prescribed combined SABA-anticholinergic reliever medications ($P < .001$) (Table I); 54.7% of patients prescribed SABA-anticholinergic relievers were also prescribed a controller medication. Only baseline SABA medications differed between general inpatient and ICU patients ($P = .024$). Patients receiving biologics for asthma therapy did not differ across groups (see Table E3 in this article's Online Repository at www.jacionline.org).

Increased risk for hospitalization versus outpatient care was significantly associated (Table II) with older age (unadjusted odds ratio [OR], 1.46; 95% CI, 1.38-1.55; $P < .001$, for every increase of 10 years), male sex (adjusted OR [aOR], 1.75; 95% CI, 1.36-2.24; $P < .001$), black (aOR, 1.65; 95% CI, 1.19-2.27; $P = .002$) and Asian (aOR, 3.19; 95% CI, 1.56-6.54; $P = .0015$) race, diabetes mellitus (aOR, 1.33; 95% CI, 1.0-1.75; $P < .05$), comorbid COPD (aOR, 1.92; 95% CI, 1.35-2.72; $P < .001$), cardiovascular disease (aOR, 1.52; 95% CI, 1.16-2.0; $P = .002$), or an active outpatient prescription for combined SABA-anticholinergic medication (aOR, 1.74; 95% CI, 1.09-2.8; $P < .05$). Sixty-two percent of hospitalized SABA-anticholinergic users also had COPD. Patients with only SABA prescriptions were less likely to be hospitalized (aOR, .59; 95% CI, 0.43-0.8; $P < .001$). Male sex, Asian race, COPD, and SABA-only remained significant after correcting for multiple comparisons (bolded aORs in Table II).

Although obesity, chronic kidney disease, and marital status were significantly associated with increased risk of ICU admission compared with general inpatient hospitalization, they were not robust to Bonferroni correction. Similarly, cardiovascular disease (aOR, 2.21; 95% CI, 1.21-4.04; $P < .01$) and male sex were the only variables that predicted higher odds of mortality but did not meet the significance threshold for multiple testing.

Several hospitalization risk factors for patients with asthma and COVID-19 reflect those identified in general populations of patients with COVID-19, including male sex, race, older age, and nonrespiratory comorbidities. Notably, male sex was a risk

**TABLE I.** Demographic and clinical characteristics of patients with a history of asthma and COVID-2019, by care setting and mortality

| | | Hospitalization (n = 1827) | | | ICU (n = 565) | | | Mortality (n = 1827) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Characteristic*** | **All patients (n = 1827)** | **Hospitalized (no) (n = 1262)** | **Hospitalized (yes) (n = 565)** | ***P* value†** | **ICU (no) (n = 329)** | **ICU (yes) (n = 236)** | ***P* value** | **Died (no) (n = 1729)** | **Died (yes) (n = 98)** | ***P* value** |
| **Demographic** | | | | | | | | | | |
| Age (y), median (IQR) | 54 (37-66) | 50 (33-61) | 63 (50-75) | <.001 | 62 (49-75) | 65 (51.75-75) | .28 | 53 (36-65) | 76 (68-85) | <.001 |
| 18-29 | 252 of 1827 (13.8) | 231 of 1262 (18.3) | 21 of 565 (3.7) | <.001 | 13 of 329 (4) | 8 of 236 (3.4) | .71 | 251 of 1729 (14.5) | 1 of 98 (1) | <.001 |
| 30-39 | 260 of 1827 (14.2) | 208 of 1262 (16.5) | 52 of 565 (9.2) | | 35 of 329 (10.6) | 17 of 236 (7.2) | | 260 of 1729 (15) | 0 of 98 (0) | |
| 40-49 | 243 of 1827 (13.3) | 180 of 1262 (14.3) | 63 of 565 (11.2) | | 37 of 329 (11.2) | 26 of 236 (11) | | 242 of 1729 (14) | 1 of 98 (1) | |
| 50-59 | 377 of 1827 (20.6) | 273 of 1262 (21.6) | 104 of 565 (18.4) | | 57 of 329 (17.3) | 47 of 236 (19.9) | | 369 of 1729 (21.3) | 8 of 98 (8.2) | |
| 60-69 | 311 of 1827 (17) | 191 of 1262 (15.1) | 120 of 565 (21.2) | | 67 of 329 (20.4) | 53 of 236 (22.5) | | 292 of 1729 (16.9) | 19 of 98 (19.4) | |
| 70-80 | 208 of 1827 (11.4) | 101 of 1262 (8) | 107 of 565 (18.9) | | 59 of 329 (17.9) | 48 of 236 (20.3) | | 178 of 1729 (10.3) | 30 of 98 (30.6) | |
| ≥80 | 176 of 1827 (9.6) | 78 of 1262 (6.2) | 98 of 565 (17.3) | | 61 of 329 (18.5) | 37 of 236 (15.7) | | 137 of 1729 (7.9) | 39 of 98 (39.8) | |
| Sex: female | 1232 of 1827 (67.4) | 892 of 1262 (70.7) | 340 of 565 (60.2) | <.001 | 199 of 329 (60.5) | 141 of 236 (59.7) | .93 | 1177 of 1729 (68.1) | 55 of 98 (56.1) | .02 |
| Race‡ | | | | | | | | | | |
| White | 1054 of 1827 (57.7) | 737 of 1262 (58.4) | 317 of 565 (56.1) | .02 | 170 of 329 (51.7) | 147 of 236 (62.3) | .01 | 980 of 1729 (56.7) | 74 of 98 (75.5) | .15 |
| Black | 297 of 1827 (16.3) | 189 of 1262 (15) | 108 of 565 (19.1) | | 68 of 329 (20.7) | 40 of 236 (16.9) | | 283 of 1729 (16.4) | 14 of 98 (14.3) | |
| Asian | 43 of 1827 (2.4) | 24 of 1262 (1.9) | 19 of 565 (3.4) | | 8 of 329 (2.4) | 11 of 236 (4.7) | | 43 of 1729 (2.5) | 0 of 98 (0) | |
| Other/unknown | 433 of 1827 (23.7) | 312 of 1262 (24.7) | 121 of 565 (21.4) | | 83 of 329 (25.2) | 38 of 236 (16.1) | | 423 of 1729 (24.5) | 10 of 98 (10.2) | |
| Ethnicity, Hispanic‡ | 494 of 1767 (28) | 359 of 1227 (29.3) | 135 of 540 (25) | .08 | 78 of 310 (25.2) | 57 of 230 (24.8) | >.99 | 483 of 1672 (28.9) | 11 of 95 (11.6) | <.001 |
| Education level‡ | | | | | | | | | | |
| College and above | 540 of 1827 (29.6) | 391 of 1262 (31) | 149 of 565 (26.4) | .03 | 80 of 329 (24.3) | 69 of 236 (29.2) | .42 | 516 of 1729 (29.8) | 24 of 98 (24.5) | .55 |
| High school or equivalent | 620 of 1827 (33.9) | 416 of 1262 (33) | 204 of 565 (36.1) | | 122 of 329 (37.1) | 82 of 236 (34.7) | | 586 of 1729 (33.9) | 34 of 98 (34.7) | |
| Did not complete high school | 242 of 1827 (13.2) | 154 of 1262 (12.2) | 88 of 565 (15.6) | | 47 of 329 (14.3) | 41 of 236 (17.4) | | 227 of 1729 (13.1) | 15 of 98 (15.3) | |
| Unknown | 425 of 1827 (23.3) | 301 of 1262 (23.9) | 124 of 565 (21.9) | | 80 of 329 (24.3) | 44 of 236 (18.6) | | 400 of 1729 (23.1) | 25 of 98 (25.5) | |
| Marital status‡ | | | | | | | | | | |
| Single | 764 of 1786 (42.8) | 566 of 1233 (45.9) | 198 of 553 (35.8) | <.001 | 130 of 319 (40.8) | 68 of 234 (29.1) | .03 | 737 of 1691 (43.6) | 27 of 95 (28.4) | <.001 |
| Married/partnered | 686 of 1786 (38.4) | 483 of 1233 (39.2) | 203 of 553 (36.7) | | 111 of 319 (34.8) | 92 of 234 (39.3) | | 661 of 1691 (39.1) | 25 of 95 (26.3) | |
| Divorced | 202 of 1786 (11.3) | 127 of 1233 (10.3) | 75 of 553 (13.6) | | 40 of 319 (12.5) | 35 of 234 (15) | | 190 of 1691 (11.2) | 12 of 95 (12.6) | |
| Widowed | 134 of 1786 (7.5) | 57 of 1233 (4.6) | 77 of 553 (13.9) | | 38 of 319 (11.9) | 39 of 234 (16.7) | | 103 of 1691 (6.1) | 31 of 95 (32.6) | |
| Insurance type | | | | | | | | | | |
| Commercial | 1065 of 1827 (58.3) | 799 of 1262 (63.3) | 266 of 565 (47.1) | <.001 | 152 of 329 (46.2) | 114 of 236 (48.3) | .1 | 1035 of 1729 (59.9) | 30 of 98 (30.6) | <.001 |
| Medicare | 455 of 1827 (24.9) | 245 of 1262 (19.4) | 210 of 565 (37.2) | | 119 of 329 (36.2) | 91 of 236 (38.6) | | 392 of 1729 (22.7) | 63 of 98 (64.3) | |
| Medicaid | 269 of 1827 (14.7) | 187 of 1262 (14.8) | 82 of 565 (14.5) | | 51 of 329 (15.5) | 31 of 236 (13.1) | | 264 of 1729 (15.3) | 5 of 98 (5.1) | |
| Others | 38 of 1827 (2.1) | 31 of 1262 (2.5) | 7 of 565 (1.2) | | 7 of 329 (2.1) | 0 of 236 (0) | | 38 of 1729 (2.2) | 0 of 98 (0) | |
| Smoking history‡ | | | | | | | | | | |
| Never smoker | 1109 of 1785 (62.1) | 817 of 1242 (65.8) | 292 of 543 (53.8) | <.001 | 164 of 310 (52.9) | 128 of 233 (54.9) | .58 | 1068 of 1690 (63.2) | 41 of 95 (43.2) | <.001 |
| Current smoker | 136 of 1785 (7.6) | 91 of 1242 (7.3) | 45 of 543 (8.3) | | 29 of 310 (9.4) | 16 of 233 (6.9) | | 131 of 1690 (7.8) | 5 of 95 (5.3) | |
| Former smoker | 540 of 1785 (30.3) | 334 of 1242 (26.9) | 206 of 543 (37.9) | | 117 of 310 (37.7) | 89 of 233 (38.2) | | 491 of 1690 (29.1) | 49 of 95 (51.6) | |
| BMI, median (IQR) | 30.23 (25.88-35.4) | 30.31 (25.98- 35.31) | 30.07 (25.82-35.59) | .55 | 29.88 (25.14-35.12) | 30.07 (25.82-35.59) | .03 | 30.38 (26.00-35.4) | 27.72 (23.00-34.31) | >.99 |
| ≤24.9 | 361 of 1812 (19.9) | 240 of 1252 (19.2) | 121 of 560 (21.6) | .48 | 78 of 324 (24.1) | 43 of 236 (18.2) | .22 | 327 of 1714 (19.1) | 34 of 98 (34.7) | <.001 |
| 25-29.9 | 509 of 1812 (28.1) | 656 of 1252 (52.4) | 153 of 560 (27.3) | | 88 of 324 (27.2) | 65 of 236 (27.5) | | 483 of 1714 (28.2) | 26 of 98 (26.5) | |
| ≥30 | 942 of 1812 (52) | 356 of 1252 (28.4) | 286 of 560 (51.1) | | 158 of 324 (48.8) | 128 of 236 (54.2) | | 904 of 1714 (52.7) | 38 of 98 (38.8) | |
| **Comorbidities§** | | | | | | | | | | |
| Diabetes mellitus | 464 of 1827 (25.4) | 246 of 1262 (19.5) | 218 of 565 (38.6) | <.001 | 123 of 329 (37.4) | 95 of 236 (40.3) | .55 | 416 of 1729 (24.1) | 48 of 98 (49) | <.001 |
| COPD | 292 of 1827 (16) | 129 of 1262 (10.2) | 163 of 565 (28.8) | <.001 | 86 of 329 (26.1) | 77 of 236 (32.6) | .11 | 246 of 1729 (14.2) | 46 of 98 (47) | <.001 |
| Chronic kidney disease | 252 of 1827 (13.8) | 112 of 1262 (8.9) | 140 of 565 (24.8) | <.001 | 69 of 329 (21) | 71 of 236 (30.1) | .02 | 206 of 1729 (11.9) | 46 of 98 (47) | <.001 |
| Chronic liver disease | 224 of 1827 (12.3) | 131 of 1262 (10.4) | 93 of 565 (16.5) | <.001 | 53 of 329 (16.1) | 40 of 236 (16.9) | .88 | 211 of 1729 (12.2) | 13 of 98 (13.3) | .88 |
| Cardiovascular disease | 589 of 1827 (32.2) | 309 of 1262 (24.5) | 280 of 565 (49.6) | <.001 | 153 of 329 (46.5) | 127 of 236 (53.8) | .1 | 515 of 1729 (29.8) | 74 of 98 (75.5) | <.001 |
| Hypertension | 837 of 1827 (45.8) | 465 of 1262 (36.8) | 372 of 565 (65.8) | <.001 | 209 of 329 (63.5) | 163 of 236 (69.1) | .2 | 758 of 1729 (43.8) | 79 of 98 (80.6) | <.001 |
| Allergic rhinitis | 518 of 1827 (28.4) | 390 of 1262 (30.9) | 128 of 565 (22.7) | <.001 | 72 of 329 (21.9) | 56 of 236 (23.7) | .68 | 500 of 1729 (28.9) | 18 of 98 (18.4) | .03 |
| Chronic rhinosinusitis | 95 of 1827 (5.2) | 67 of 1262 (5.3) | 28 of 565 (5) | .84 | 18 of 329 (5.5) | 10 of 236 (4.2) | .56 | 90 of 1729 (5.2) | 5 of 98 (5.1) | >.99 |
| Atopic dermatitis | 51 of 1827 (2.8) | 33 of 1262 (2.6) | 18 of 565 (3.2) | .6 | 7 of 329 (2.1) | 11 of 236 (4.7) | .14 | 48 of 1729 (2.8) | 3 of 98 (3.1) | .75 |
| **Controller medications‖** | | | | | | | | | | |
| ICS | 310 of 1827 (17) | 227 of 1262 (18) | 83 of 565 (14.7) | .095 | 54 of 329 (16.4) | 29 of 236 (12.3) | .21 | 297 of 1729 (17.2) | 13 of 98 (13.3) | .39 |
| ICS-LABA combination | 289 of 1827 (15.8) | 185 of 1262 (14.7) | 104 of 565 (18.4) | .05 | 63 of 329 (19.1) | 41 of 236 (17.4) | .67 | 274 of 1729 (15.8) | 15 of 98 (15.3) | >.99 |
| Anticholinergic | 73 of 1827 (4) | 40 of 1262 (3.2) | 33 of 565 (5.8) | .01 | 20 of 329 (6.1) | 13 of 236 (5.5) | .92 | 66 of 1729 (3.8) | 7 of 98 (7.1) | .11 |
| Biologic¶ | 16 of 1827 (.9) | 11 of 1262 (.9) | 5 of 565 (.9) | .49 | 2 of 329 (.61) | 3 of 236 (1.3) | .65 | 15 of 1729 (.9) | 1 of 98 (1) | .59 |
| Leukotriene modifier | 134 of 1827 (7.3) | 86 of 1262 (6.8) | 48 of 565 (8.5) | .24 | 29 of 329 (8.8) | 19 of 236 (8.1) | .87 | 127 of 1729 (7.3) | 7 of 98 (7.1) | >.99 |
| **Reliever medications‖** | | | | | | | | | | |
| SABA | | | | | | | | | | |
| SABA-only | 392 of 1827 (21.5) | 302 of 1262 (23.9) | 90 of 565 (15.9) | <.001 | 42 of 329 (12.8) | 48 of 236 (20.3) | .02 | 380 of 1729 (22) | 12 of 98 (12.2) | .045 |
| With controller | 450 of 1827 (24.6) | 316 of 1262 (25) | 134 of 565 (23.7) | | 87 of 329 (26.4) | 47 of 236 (19.9) | | 427 of 1729 (24.7) | 23 of 98 (23.5) | |

*(Continued)*

**TABLE I.** *(Continued)*

| Characteristic* | All patients (n = 1827) | Hospitalization (n = 1827) | | | ICU (n = 565) | | | Mortality (n = 1827) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Hospitalized (no) (n = 1262) | Hospitalized (yes) (n = 565) | *P* value† | ICU (no) (n = 329) | ICU (yes) (n = 236) | *P* value | Died (no) (n = 1729) | Died (yes) (n = 98) | *P* value |
| None | 985 of 1827 (53.9) | 644 of 1262 (51) | 341 of 565 (60.4) | | 200 of 329 (60.8) | 141 of 236 (59.7) | | 922 of 1729 (53.3) | 63 of 98 (64.3) | |
| SABA-anticholinergic combination | 106 of 1827 (5.8) | 48 of 1262 (3.8) | 58 of 565 (10.3) | <.001 | 32 of 329 (9.7) | 26 of 236 (11) | .72 | 92 of 1729 (5.3) | 14 of 98 (14.3) | <.001 |
| **Death#** | 98 of 1827 (5.4) | 10 of 1262 (.8) | 88 of 565 (15.6) | <.001 | 33 of 329 (10) | 55 of 236 (23.3) | <.001 | 0 of 98 (0) | 98 of 98 (100) | NA |

*BMI*, Body mass index; *FDA*, Food and Drug Administration; *ICD*, *International Classification of Diseases*; *IQR*, interquartile range; *LABA*, long-acting beta-agonist.
*Data reflect patients diagnosed with COVID-19 between March 3, 2020, and May 20, 2020. Of 78,870 patients tested for COVID-19 in this period, 60.2% (n = 47,468) were female. Characteristics (except death) as of date of COVID-19 diagnosis.
†All *P* values are unadjusted.
‡Self-reported.
§As recorded by *ICD* code or problem list in the electronic health record. Diabetes mellitus includes type 1 and type 2. Chronic rhinosinusitis includes with and without nasal polyps.
‖Active prescription initiated within the 12 months before COVID-19 diagnosis.
¶With an FDA-approved indication for asthma.
#Mortality data collected until June 8, 2020.

**TABLE II.** Risk factors associated with hospitalization, intensive care, and mortality among patients with a history of asthma and COVID-2019

| Variable | Hospitalization | | ICU | | Mortality | |
|---|---|---|---|---|---|---|
| | Univariable analysis (n = 1827)* | Multivariable analysis (n = 1717)† | Univariable analysis (n = 565)* | Multivariable analysis (n = 543)† | Univariable analysis (n = 1827)* | Multivariable analysis (n = 1678)† |
| Age | **1.46 (1.38-1.55)**‡ | NA | 1.03 (0.94-1.13)‡ | NA | **2.25 (1.95-2.63)**‡ | NA |
| Sex: male | **1.64 (1.32-2.05)** | **1.75 (1.36-2.24)**§ | 1.04 (0.73-1.46) | NA | 1.7 (1.1-2.62) | 1.95 (1.16-3.26)‖ |
| Race | | | | | | |
| White | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | NA |
| Black | **1.69 (1.26-2.26)** | **1.65 (1.19-2.27)**¶ | 0.67 (0.43-1.06) | 0.68 (0.42-1.1) | 0.94 (0.51-1.75) | NA |
| Asian | **3.01 (1.55-5.85)** | **3.19 (1.56-6.54)**¶ | 1.5 (0.58-3.85) | 2.16 (0.79-5.92) | NA | NA |
| Other/unknown | 1.28 (0.98-1.67) | .93 (0.61-1.42) | 0.51 (0.32-0.81) | 0.6 (0.37-0.99)‖ | 0.61 (0.3-1.23) | NA |
| Ethnicity, Hispanic | 1.11 (0.87-1.42) | 1.34 (0.9-1.98) | 0.98 (0.66-1.47) | NA | 0.6 (0.31-1.17) | 0.83 (0.41-1.71) |
| Marital status | | | | | | |
| Single | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Married/partnered | 0.78 (0.6-1) | 0.94 (0.72-1.25) | 1.59 (1.05-2.39) | 1.56 (1.01-2.41)‖ | 0.58 (0.32-1.04) | 0.6 (0.32-1.11) |
| Divorced | 0.89 (0.63-1.27) | 0.92 (0.63-1.36) | 1.69 (0.97-2.96) | 1.7 (0.95-3.03) | 0.69 (0.33-1.43) | 0.69 (0.31-1.51) |
| Widowed | 1.31 (0.85-2) | 1.41 (0.88-2.28) | 2.32 (1.27-4.24) | 2.17 (1.15-4.09)‖ | 1.53 (0.83-2.82) | 1.85 (0.93-3.71) |
| Education level | | | | | | |
| College and above | 1.0 | 1.0 | 1.0 | NA | 1.0 | NA |
| High school or equivalent | 1.37 (1.05-1.78) | 1.13 (0.84-1.53) | 0.77 (0.5-1.18) | NA | 1.16 (0.66-2.03) | NA |
| Did not complete high school | 1.54 (1.1-2.17) | 1.17 (0.78-1.75) | 0.99 (0.59-1.69) | NA | 1.33 (0.66-2.68) | NA |
| Unknown | 1.02 (0.76-1.37) | 0.84 (0.6-1.18) | 0.63 (0.39-1.03) | NA | 1.12 (0.61-2.04) | NA |
| Insurance type | | | | | | |
| Commercial | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Medicaid | 1.64 (1.21-2.24) | 1.21 (0.84-1.74) | 0.85 (0.51-1.42) | 1.05 (0.61-1.84) | NA | 0.97 (0.31-3.04) |
| Medicare | 1.18 (0.89-1.56) | 0.93 (0.68-1.27) | 1.04 (0.69-1.57) | 1.04 (0.67-1.62) | 1.56 (0.94-2.59) | 1.47 (0.85-2.52) |
| Others | 0.97 (0.41-2.27) | 0.61 (0.22-1.68) | NA | NA | NA | NA |
| Smoking history | | | | | | |
| Never smoker | 1.0 | 1.0 | 1.0 | NA | 1.0 | 1.0 |
| Current smoker | 1.41 (0.95-2.1) | 0.82 (0.51-1.3) | 0.68 (0.35-1.32) | NA | 1.23 (0.46-3.29) | 0.66 (0.23-1.93) |
| Former smoker | 1.1 (0.87-1.4) | 0.84 (0.64-1.11) | 0.97 (0.66-1.41) | NA | 1.21 (0.77-1.91) | 0.74 (0.44-1.26) |
| BMI | 1.01 (1-1.03) | NA | 1.03 (1-1.05) | 1.03 (1-1.05)‖ | 1 (0.97-1.03) | 0.99 (0.96-1.02) |
| **Comorbidities** | | | | | | |
| Diabetes mellitus | **1.82 (1.44-2.3)** | 1.33 (1.02-1.75)‖ | 1.09 (0.76-1.54) | NA | 1.67 (1.09-2.58) | 1.27 (0.76-2.11) |
| COPD | **1.96 (1.47-2.6)** | **1.92 (1.35-2.72)**§ | 1.41 (0.94-2.11) | 1.33 (0.84-2.1) | 1.74 (1.11-2.73) | 1.51 (0.88-2.6) |
| Chronic kidney disease | **1.76 (1.29-2.39)** | 1.22 (0.86-1.73) | 1.83 (1.18-2.83) | 1.64 (1.02-2.62)‖ | 1.94 (1.21-3.1) | 1.42 (0.83-2.43) |
| Chronic liver disease | **1.64 (1.22-2.22)** | 1.31 (0.94-1.82) | 1.34 (0.93-1.93) | NA | 1.29 (0.68-2.45) | NA |
| Cardiovascular disease | **1.91 (1.51-2.41)** | 1.52 (1.16-2)¶ | 1.26 (0.84-1.88) | 1.03 (0.68-1.55) | **2.75 (1.66-4.55)** | 2.21 (1.21-4.04)¶ |
| Hypertension | **1.92 (1.51-2.45)** | 1.32 (0.99-1.77) | 1.11 (0.75-1.66) | NA | 1.38 (0.79-2.41) | 1.09 (0.52-2.26) |
| Allergic rhinitis | **0.66 (0.52-0.84)** | 0.77 (0.59-1.01) | 1.83 (1.18-2.83) | NA | 0.64 (0.37-1.11) | 0.73 (0.39-1.35) |
| **Medications** | | | | | | |
| ICS | 0.66 (0.52-0.84) | 0.92 (0.61-1.39) | 0.73 (0.45-1.19) | NA | 0.85 (0.45-1.59) | NA |

*(Continued)*

**TABLE II.** *(Continued)*

| Variable | Hospitalization | | ICU | | Mortality | |
|---|---|---|---|---|---|---|
| | Univariable analysis (n = 1827)* | Multivariable analysis (n = 1717)† | Univariable analysis (n = 565)* | Multivariable analysis (n = 543)† | Univariable analysis (n = 1827)* | Multivariable analysis (n = 1678)† |
| ICS-LABA combination | 1.01 (0.76-1.33) | 1.08 (0.73-1.59) | 0.84 (0.54-1.3) | NA | 0.65 (0.36-1.18) | NA |
| Anticholinergic | 1.41 (0.86-2.3) | 0.74 (0.41-1.34) | 0.87 (0.42-1.79) | NA | 1.32 (0.57-3.08) | NA |
| SABA | | | | | | |
| SABA none | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| SABA-only | 0.65 (0.49-0.86) | **0.59 (0.43-0.8)**§ | 0.62 (0.39-1) | 1.6 (0.98-2.62) | 0.72 (0.37-1.39) | 0.74 (0.36-1.51) |
| With controller | 0.76 (0.59-0.98) | 0.73 (0.48-1.11) | 0.46 (0.27-0.8) | 0.65 (0.42-1.02) | 0.83 (0.5-1.39) | 0.85 (0.47-1.53) |
| SABA-anticholinergic combination | **1.99 (1.31-3.01)** | 1.74 (1.09-2.8)‖ | 1.13 (0.65-1.97) | NA | 1.54 (0.81-2.91) | 1.23 (0.61-2.48) |

*BMI*, Body mass index; *LABA*, long-acting beta-agonist.
Values are OR (95% CI). Text in boldface indicates statistical significance after Bonferroni correction for multiple testing, with significance level set at $P < .0016$.
*Age-stratified logistic regression analysis was applied to all individual variables except age.
†Age-stratified multivariable analysis with the variables listed in the present table. Variables were chosen on the basis of $P \leq .1$ calculated using Wilcoxon test, $\chi^2$ test, or Fisher exact test. "NA" indicates that the corresponding variable or variable category was not included for the multivariable analysis.
‡The OR and CI were reported for an increase in age by 10 years.
§$P < .001$.
‖$P < .05$
¶$P < .01$

factor despite female predominance in COVID-19 testing and in positive diagnosis among patients with asthma.

In distinguishing asthma within chronic respiratory disease categorization, we found that a comorbid diagnosis of COPD was a strong risk factor for hospitalization, and the only comorbidity that remained statistically significant after correction for multiple comparisons. Mild asthma managed with SABA alone was more common in patients triaged to outpatient care, and these patients were less likely to be hospitalized. In contrast, we found no differences in risk for hospitalization or ICU-level care with ICS or combined ICS-long-acting beta-agonist use. Asthma-specific variables did not predict ICU care or mortality, and the differences between risk for inpatient hospitalization and ICU admission are a compelling area for future investigation.

MGB health system serves the largest volume of hospitalized patients with COVID-19 in New England. However, despite having an MGB primary care provider, some patients may have sought COVID-19 care out of our hospital system. Asthma prevalence in MGB COVID-19–positive patients (13.1%) is within range of chronic respiratory disease and/or COPD (4.6%-15.6%) rates from China COVID-19 studies[4,5,9] and slightly higher than the asthma prevalence in a large New York City cohort (9%).[7] Electronic health record prescription data are not linked to pharmacy fill data; future research could use administrative claims data to strengthen associations with baseline asthma medication use. Finally, a small number of patients remained hospitalized at the time of censoring, which may have led to underreporting of subsequent ICU admissions or deaths. Available data support that mortality was similar for patients with COVID-19 with or without asthma in the MGB outpatient and inpatient settings.

Our findings highlight the importance of distinguishing asthma from chronic pulmonary diseases in COVID-19 research to establish an evidence base for risk evaluation and suggest that individuals with asthma-COPD overlap may be especially at risk. Further research examining the course of hospitalized patients is necessary to elucidate predictors of disease progression and clinical outcomes.

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*Liqin Wang, PhD*[a]
*Dinah Foer, MD*[b]
*David W. Bates, MD, MSc*[a]
*Joshua A. Boyce, MD*[b]
*Li Zhou, MD, PhD*[a]

From the [a]Divisions of General Internal Medicine and Primary Care and [b]Allergy and Clinical Immunology, Department of Medicine, Brigham and Women's Hospital and Harvard Medical School, Boston, Mass. E-mail: lwang@bwh.harvard.edu.

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Disclosure of potential conflict of interest: D. W. Bates consults for EarlySense, which makes patient safety monitoring systems; receives cash compensation from CDI (Negev), Ltd, which is a not-for-profit incubator for health IT startups; receives equity from ValeraHealth, which makes software to help patients with chronic diseases, Clew, which makes software to support clinical decision making in intensive care, MDClone, which takes clinical data and produces deidentified versions of it, and AESOP, which makes software to reduce medication error rates; and will be receiving research funding from IBM Watson Health. These financial interests have been reviewed by Brigham and Women's Hospital and Partners HealthCare in accordance with their institutional policies. J. A. Boyce reports consultant work for Sanofi and sits on the Scientific Advisory Board for Siolta Therapeutics and Sanofi-Aventis. The rest of the authors declare that they have no relevant conflicts of interest.

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