Cityblock Health cares for populations at high risk for Covid-19 complications if they contract the disease. In an effort to enable their care teams to strategically and thoughtfully assist patients in the wake of the Covid-19 pandemic, they’ve built a rules-based, adaptable model to identify which Covid-19 patients are at highest risk of hospitalization or intensive care unit (ICU) use. They have summarized evidence, currently available across various sources, and built an actionable model using claims and electronic health record data. The authors cannot currently validate the tool given the constantly evolving pandemic, but they provide the criteria and associated codes to help other provider groups, health systems, and health plans more easily adopt and implement the model. Their hope is that other providers and health care systems can rapidly identify patients at elevated risk and provide those patients and their loved ones with additional preventive services, health education, virtual care, and in-home medical services as needed.

About Cityblock and Covid

Cityblock Health partners with payers and at-risk providers, taking capitated financial risk to pay for these providers’ and payers’ most vulnerable members. We provide care in three cities on the East Coast, including New York City, the epicenter of the United States pandemic where there have been over 42,400 hospitalizations for coronavirus disease 2019 (Covid-19).¹ We aim to radically improve the health of urban communities, one block at a time. Our teams deliver technology-
enabled personalized primary care, behavioral health, and social services in our members’ homes, communities, and neighborhood clinics.

Our 10,000 members are primarily Medicaid, dual-eligible, and lower-income Medicare and commercially insured beneficiaries living in predominantly low-income communities of color in New York, Connecticut, and Massachusetts. They have an average age of 58, and 90% have three or more chronic conditions. A large proportion of our members also face unstable housing, uncertain food access, or lack of social support. They utilize the emergency department, inpatient admissions, and skilled nursing facilities (SNFs) at higher rates than the general population.

With high underlying rates of social, behavioral, and health risk factors, our members are particularly at risk to develop severe Covid-19 symptoms. Realizing the elevated risk of Covid-19 to our members, we wanted to identify our highest-risk members and target them for education, services, and symptom management if they contract the disease. Recognizing the importance of a coordinated response and shared learnings, we wanted to produce an open-source tool to help other providers and health care organizations identify their patients at highest risk of hospitalization, ICU use, and death from Covid-19.

**Developing a Model: What Do We Know?**

Evidence from countries with advanced Covid-19 outbreaks has shown that age and some underlying conditions are associated with severe Covid-19 disease. A few studies suggest relationships between specific common medical conditions and Covid-19 exacerbation, and the Centers for Disease Control and Prevention lists possible underlying risk factors. However, we are not aware of any comprehensive models that identify conditions and factors related to an elevated risk of serious illness from Covid-19, and simple lists of conditions are not actionable for care teams or clinical leadership. When Covid-19 cases started spiking in Washington state, we began developing a rules-based model to identify members at the highest risk of hospitalization or ICU use/death if they contract Covid-19.

Research in late February by the World Health Organization (WHO) on 55,924 laboratory-confirmed infections in China found an overall crude fatality rate of 3.8%, and categorized cases based on disease severity:

- Non-severe: 80% of cases with mild or moderate symptoms
- Severe: 14% of cases, required hospitalization on general care floors
- Critical: 6.1% of cases, required ICU or critical care

*Noteably, this population breakdown likely does not include asymptomatic individuals, and recent reporting suggests substantial undercounts of cases and deaths in China.*
Other studies have since employed these categories and compared patient characteristics by category. Our rules-based model aggregates evidence from across studies and uses simple rules to identify which characteristics are likely to put a member in one of these categories if they contract the disease. We identified conditions and factors that put members at high risk (those most likely to experience critical disease as defined by WHO), moderate risk (those most likely to experience severe disease) and low risk (those not at elevated risk for critical or severe disease). See Table 1 for a full list of the conditions and factors associated with each risk level.

Our approach is intentionally simplistic. We avoid any risk scoring beyond the high, moderate, and low categories because the existing data are very preliminary and based on small sample sizes, as well as observational studies that cannot imply causality. We believe the risk factors we have incorporated into the algorithm flag members with increased risk of complications as a consequence of contracting Covid-19. The model likely overidentifies those at highest risk. Without more detailed evidence, we erred on the side of overidentification of highest risk cases for priority, person-level engagement, and further risk assessment. We are actively tracking and providing

| Table 1. Cityblock Covid-19 Risk Rules-Based Model Criteria |
|-----------------------------------------------------------|
| **Moderate Risk:** At risk for severe illness/acute utilization |
| age ≥ 18 AND any of the following: |
| Uncontrolled asthma (acute utilization in the previous rolling 12 months with a primary diagnosis of asthma)8,12 |
| Moderate to severe systolic/diastolic heart failure13 |
| Coronary artery disease,5,14 cardiovascular disease7,13,15 |
| Recent history of aspiration pneumonia |
| Autonomic dysfunction |
| Current end stage renal disease (ESRD) on dialysis8 |
| Current homelessness8 |
| OR |
| age ≥ 503 AND any of the following: |
| Lives in a group home, SNF, nursing facility, custodial care facility, hospice, inpatient rehabilitation8,16 |
| Hypertension5,14,17 |
| Pulmonary Diagnoses: COPD including emphysema,4 asthma,4,5 any type, pulmonary fibrosis/ IPF, lung volume reduction, cystic fibrosis5,14 |
| Immune Suppression4,12 |
| o Active cancer11,12 |
| o Diagnoses: HIV/AIDS,8 lupus, rheumatoid arthritis, Crohn’s disease, ulcerative colitis, multiple sclerosis, psoriasis, sarcoid (lung) or history of organ transplant,18 hepatitis B,19 end stage liver disease20 |
| o Medications: Corticosteroids (prednisone, budesonide, prednisolone, tofacitinib, cyclosporine, tacrolimus, sirolimus, everolimus, azathioprine, leflunomide, mycophenolate, abatacept adalimumab, anakinra, certolizumab, Etanercept, golimumab, infliximab, ixekizumab, natalizumab, rituximab, secukinumab, tocilizumab, ustekinumab, vedolizumab, basiliximab, daclizumab; any chemotherapy Metabolic (diabetes5,14,17 or BMI> 3021) Neurologic/neuromuscular (dysphagia, Parkinson’s, stroke/cerebrovascular disease,6,7 ALS22 |
| Renal Disease (CKD 3, CKD 4, CKD 5)4,23,24 |
| **High Risk:** At risk for need for critical care (ICU)/very serious illness |
| Among the Moderate Risk population: |
| age ≥ 80 AND |
| o any of the previous risk factors11 |
| OR |
| age ≥ 60 AND |
| o 2+ of the above risk factors |
| OR |
| age ≥ 18 AND |
| Ventilator dependent (in 2020) |
| Has a tracheostomy (in 2020) |
| Quadriplegia |
| Cancer that is actively being treated with chemotherapy12 |
| **Low Risk:** Not at elevated risk for critical or severe disease |
| Patients who do not meet the criteria for High or Moderate Risk |

Source: The authors
care, where appropriate, to our lab-confirmed positive, likely Covid-positive based on symptoms, and asymptomatic but exposed members. Over the coming months we will use a combination of our tracker, and encounter data from claims, to validate the model in our population. We expect that higher percentages of our population will experience critical and severe Covid-19 than demonstrated so far in the general population.

Building the Model: The Details

We derived the model criteria from available studies and government reports, preprint and published, between January 1, 2020, and April 1, 2020, which we gathered by searching PubMed and medRxiv (preprint repository) and reviewing all titles/abstracts that included epidemiologic profiles and comorbidities of Covid-positive individuals. For non–peer reviewed preprint articles we performed our own peer review before including information from these articles in the model. Using the selected articles, we compared the characteristics of patients who died, went to the ICU, were hospitalized, or had moderate symptoms.

“A large proportion of our members also face unstable housing, uncertain food access, or lack of social support. They utilize the emergency department, inpatient admissions, and skilled nursing facilities at higher rates than the general population.”

After finalizing the relevant conditions and risk factors (e.g., age, homelessness), our clinical and data teams partnered to create the relevant logic and apply it to the data we have on our members. We used a combination of relevant Hierarchical Condition Categories (HCCs), ICD-10 codes, CPT codes, National Drug Code (NDC) categories, and place of service (POS) codes to best identify conditions in our data. We include both the criteria (e.g., diagnosis or characteristic) and the logic used to identify individuals, shown in Table 2. The model requires medical claims or electronic health record data, which capture comorbidities and medical encounter history, but will be more comprehensive if both data sources are included.

We developed three models between March 12 and April 1, based on the evidence available at the time. Our original model, developed on March 12, included individuals over age 50 in the high- and moderate-risk categories, as available studies were primarily based on data sets from China and Italy, where the majority of the hospitalized populations were older than 50. Serious illness requiring hospitalization or intensive care and deaths have since been reported among younger individuals in the United States. Most of the existing reports and studies including younger populations either are missing data on comorbidities or only assess each risk factor independently, so we cannot determine interaction effects between age and comorbidities. Recognizing these limitations, we interpreted the evidence to suggest that, on average, younger individuals with chronic conditions remain at proportionally lower risk of advanced illness from Covid-19 than older individuals with the same conditions.
### Table 2. Diagnosis/Characteristic Flags and Corresponding Codes/Identification Criteria

| Flag                                                                 | Codes/Clinical Criteria                                                                 | Time Frame                                      |
|----------------------------------------------------------------------|----------------------------------------------------------------------------------------|-------------------------------------------------|
| Lives in a group home, SNF, nursing facility, custodial care facility, hospice, inpatient rehabilitation | POS = 14, 31, 32, 33, 34, 61 Members that had at least a claim in these POS, for 3 consecutive months between September 2019 and February 2020 | for ≥ 3 months in the last 6 months |
| Asthma                                                              | ICD10: J45.X Uncontrolled asthma has asthma as primary diagnosis in an acute setting (Inpatient/ED/Observation) | Ever in claim set Last 12 months               |
| CAD/CVD disease                                                     | ICD10: I20.X, I23.X, I24.X, I25.X HCC: 107, 108 | Ever in claim set                              |
| Hypertension                                                       | ICD10: H35031, H35032, H35033, H35039, I10, I110, I119, I120, I129, I130, I1310, I1311, I132, I150, I151, I152, I158, I159, I1674, N262 | In 2019 or 2020                               |
| Pulmonary diagnosis: COPD, pulmonary fibrosis/ IPF, lung volume reduction, cystic fibrosis | COPD: ICD10: J40, J41.0, J41.1, J41.8, J42, J43.0, J43.1, J43.2, J43.8, J44.0, J44.1, J44.9, J47.0, J47.1, J47.9 Pulmonary Fibrosis: ICD10: J84.X Lung Volume reduction: CPT/HCPCS: 32491, 32672, G0302, G0303, G0304, G0305 ICD-10-PCS: 0BBC0ZZ, 0BBC4ZZ, 0BBD0ZZ, 0BBD4ZZ, 0BBF0ZZ, 0BBF4ZZ, 0BBG0ZZ, 0BBG4ZZ, 0BBH0ZZ, 0BBH4ZZ, 0B Bj0ZZ, 0BBK0ZZ, 0BBK4ZZ, 0BBL0ZZ, 0BBL4ZZ, 0BBM0ZZ, 0BBM4ZZ Cystic Fibrosis: ICD10 E84.X | Ever in claim set |
| Immunosuppression diagnoses: HIV, AIDS, lupus, rheumatoid arthritis, Crohn’s disease, ulcerative colitis, end-stage liver disease, multiple sclerosis, psoriasis, h/o organ transplant, active cancer | HIV: B97.35, Z22 AIDS: B20.X-B24.X Lupus: ICD10: M32.X Psoriasis: ICD10: L40.X Rheumatoid arthritis: ICD10: M05.X, M06.X Crohn’s disease: ICD10: K50.X Multiple Sclerosis: ICD10: G35.X Organ Transplant: ICD10: Z94.X Other immunodeficiency disorders: ICD10: D80.X-D83.X, D86.X Inflammatory Bowel Disease: HCC 35 Hepatitis B: B16.X, B17.0, B18.0, B18.1 End Stage Liver Disease: K72.X Active Cancer: HCC: 8, 9, 10, 11, 12 Medications: NDC: See Appendix for full list search string Chemotherapy: CPT J9000 – J9999; ICD10: Z51.11 | In 2019 or 2020 (except active cancer) Last 12 months for active cancer |
| Metabolic (Diabetes or BMI >30)                                      | Diabetes: HCC: 17, 18, 19 Obesity: HCC: 22; ICD10: Z68.3X, Z68.4X | In 2019 or 2020                               |
| Neurologic/neuromuscular (dysphagia, Parkinson's, cerebral palsy, stroke, cerebrovascular disease, ALS) | ALS: ICD10: G1221 Parkinson’s: ICD10: G20X Stroke/Cerebrovascular Disease: ICD10: G45.0, G45.1, G45.2, G45.8, G45.9, G97.31, G97.32, G97.85, I6X, I97.8X Cerebral Palsy: ICD10: G80.1, G80.2, G80.4, G80.8, G80.9 Dysphagia: ICD10: R13.X | In 2019 or 2020 (except stroke, cerebrovascular disease, and cerebral palsy) Stroke, cerebrovascular disease, and cerebral palsy ever in claim set |
| Renal disease (CKD 3 or greater), end-stage renal disease           | CKD: ICD10: N18.3, N18.4, N18.5 ESRD: ICD10: N18.6 | In 2019 or 2020                               |
| Ventilator dependent                                                | ICD10: Z99.11, Z99.12 | 2020 only and not during an inpatient stay |
| Tracheostomy status                                                 | ICD10: Z99.0 | 2020 |
| Quadriplegia                                                        | ICD10: G82.5X, G80.0 | Ever in claim set |
| Homelessness (shelter, living outside, or no home)                 | ICD10: Z90.0 (homelessness) or from social needs assessment (organization specific) | Last 6 months claims |
| Recent history of aspiration pneumonia                              | ICD10: J69.0 | 2019 or 2020 |
| Autonomic dysfunction                                               | ICD10: G90.X | 2019 or 2020 |
| Severe congestive heart failure                                     | ICD10: I50.4X; I50.814; I50.82; I50.83; I50.84. Or I50.X with Home Oxygen: Z99.81 | 2019 or 2020 |

Source: The authors
We encourage other social determinants–oriented providers to similarly adopt simplified tools to maximize understanding of the highest-risk variables during the Covid-19 pandemic, and offer our tool as an option for use."

In our second model, we removed smoking as an independent risk factor and added end-stage liver disease, decreasing the number of members in the high- or moderate-risk categories by 2.2 percentage points. For our third model update, we opened the age range to members 18 or older for those with uncontrolled asthma, severe disability indicators, and a small number of immunocompromised and autoimmune conditions. These additions were based on validation from our clinicians’ insight, and supported by recommendations from specialty associations and recent news reports suggesting high infection and case fatality rates in group homes for disabled populations. Given the low incidence of these conditions in the general population, few studies have assessed these diagnoses as independent risks for severe Covid-19 complications among the small number of Covid-positive individuals with these conditions. We also note limited examination in the literature thus far on social factors, other than homelessness and living in a group home, which may elevate risk of adverse outcomes. We will continue to monitor the literature and update the model as new information becomes available.

Model Use and Impacts

We developed the model to ensure our highest-risk members and their loved ones are comprehensively educated and monitored by our care teams. Across our markets, we identified a large percentage of our population as high or moderate risk, which is not surprising given that we care for our partner health plans’ highest-cost and highest-risk members. We anticipate that other organizations with less complex patients will identify a smaller percentage of their population as high risk for Covid-19 complications.

We provided our care teams with a list of all high- and moderate-risk members immediately following the first model output, and began telephonic, SMS, and video-based outreach. Additionally, we incorporated the risk score into Commons, our custom-built care facilitation platform, and added the risk level on each member’s profile to help direct member care. During outreach, we ask members about any challenges to staying safe and healthy while sheltering in place. We conduct an assessment including a standard Covid-19 symptom and exposure screening, as well as using a social needs tool (Figure 1) to identify potential social risk factors caused or exacerbated by the current Covid-19 societal ramifications (e.g., job loss, inability to access food or medication, home care discontinuation).
We’ve built dashboards to track assessment completion and responses, and we use assessment answers to help target clinical and social services, resources, and Covid-19 education to members and their caregivers, first prioritizing those high- and moderate-risk members and then conducting the full assessment with low-risk members. Positive responses to symptom-related questions trigger clinical evaluation.

### Outreach Prompt and Assessment Questions

We include this tool, as it may be of use to other providers caring for socioeconomically vulnerable populations.

How are you doing? We wanted to check in with you during this time to understand how you’re managing with the coronavirus situation. We can help if and when you have symptoms, can provide recommendations around the best ways to stay healthy, and can assist with resources for specific challenges you’re facing right now [food access, medication delivery, resources around financial challenges, testing sites, medical consultation, caregiver support, and more].

Would you be open to a few questions so I can better understand what you might need help with during this time?

### Assessment questions

1. Do you have enough food for the next week?
   a. If no: Do you have enough food for the next two days?
2. Are you or a caregiver/helper able to get to a grocery store or pantry to help you get additional food?
3. For each of the medications that you take every day:
   a. Do you have a least a month’s supply?
      i. If no, are you able to get to a pharmacy or get medication delivered if you need refills?
   1. If no, how many days will your current medication cover?
4. Are there any medical supplies that you regularly use that you will run out of within the next 30 days? (wound care supplies, injection supplies, drain care)
   a. If yes: How many days will your current supply last?
   b. If yes: What are the supplies? Are you or a helper able to get to a medical supply store safely or receive delivery?
5. Are the various shutdowns and cancellations affecting you financially?
   a. If yes: Do you have a plan for this month to cover the cost of basic needs (food, rent, utilities)? Do you have a plan for the following month?
6. Do you have a stable place to stay over the next 3 months?
   a. If no, do you have a place to stay over the next week?
7. Do you have family/friends/supports in your home? If not, within walking distance?
   a. If no: Do you have a plan for if and when you have symptoms or are sick? A backup plan?
8. Do you currently rely on homecare (home attendant, personal care assistant, home nursing) each week?
   a. If yes: Have these services been discontinued?
      i. If yes: Do you have a plan to cover your needs this month? Next month?
9. If you needed to get to an urgent clinical appointment right now (e.g., dialysis, new urgent symptoms), would you have a way to get there?
10. Do you have any other concerns or worries that we can help you with?

Source: The authors

NEJM Catalyst (catalyst.nejm.org) © Massachusetts Medical Society
We are seeing a substantial increase in members unable to pay for or access food and necessities such as medications, medical and cleaning supplies, and diapers."

Notably, this Covid tool is a meaningful departure from Cityblock’s usual member screening and assessment approach, which provides for substantially deeper understanding of our members’ needs through nuanced branching logic and comprehensive assessments. We elected for a simple, Covid-focused tool to ensure consistency of use and to maximize volume of member assessments completed in a short period of time. We encourage other social determinants-oriented providers to similarly adopt simplified tools to maximize understanding of the highest-risk variables during the Covid-19 pandemic, and offer our tool as an option for use.

At a population level, changing trends in aggregate member needs (food, medication access, etc.) are reviewed by practice leadership to ensure appropriate focus on specific strategies. Within 2 weeks, we connected with 67% of the high- and moderate-risk members in our active population across all markets. Consistent with our model, we regularly reach out to the remainder of our members and do a full Covid assessment when we make contact with them.

For members with a positive Covid test, positive Covid symptom screen, or known exposure, we have built a Covid-19 triage and escalation tool to track and follow up with members. Covid-positive or likely positive members receive clear and tailored instructions about red flag signs and symptoms to watch out for, and daily telemedicine follow-ups from our clinical team until symptom resolution. To support telemedicine visits, some members are provided with remote monitoring tools such as pulse oximeters and thermometers. We are also using Cityblock palliative care clinicians if members want to discuss and document goals of care and plan supportive care in place, as well as urgent in-home visits if symptoms worsen, behavioral health virtual visits if urgent behavioral health needs are identified, and emergency medical services if clinically indicated.

We are seeing a substantial increase in members unable to pay for or access food and necessities such as medications, medical and cleaning supplies, and diapers. To address these barriers and help members stay safe and in their homes, particularly the high- and moderate- Covid-19 risk populations, we’ve developed targeted programs to deliver food, and have connected with courier services and local mutual aid providers to deliver other necessary goods. We anticipate continued social challenges for our members, even as the case rate begins to flatten. To measure impacts on member outcomes, we are also conducting evaluations of our overall Covid-19 response and specific programs such as palliative care.

Key Learnings and Recommendations

Below we highlight key organizational needs that ensure model outputs are actionable for care teams and members:

Clear messaging about the model output. Care teams were initially confused about the purpose of the risk model. We recommend clearly communicating that the model is NOT...
intended to identify those at highest risk of contracting Covid-19, but instead those at highest risk of complications if they contract the disease. We also recommend emphasizing that it is possible for someone who falls into the low-risk category to experience serious morbidity/mortality if they contract Covid-19, but we believe their risk of these outcomes is materially lower.

**Use the model for prioritization of proactive outreach.** As our model is based on constantly changing evidence, it is possible we may miss some members or flag others as high-risk incorrectly. We strongly recommend using the model to inform which members are prioritized for outreach, education, and monitoring, but NOT to determine who does and does not receive care. We recommend that all members across risk categories be engaged and assessed, especially those in lower-income communities where social needs are significantly exacerbated by the Covid-19 pandemic.

> We strongly recommend using the model to inform which members are prioritized for outreach, education, and monitoring, but NOT to determine who does and does not receive care.

**Clear messaging about model changes.** As new data become available and the model changes, provide a simple summary of the changes before the patient-level data is shared. Then provide a list of members who have changed categories and what factor(s) caused the change. Where possible, minimize change fatigue by pushing list re-prioritization seamlessly and within existing workflows of outreach and care management teams. Additionally, ensure that you show Covid risk level on members’ profiles, whether in medical records or care management platforms, to allow care team members immediate access to information about Covid risk along with underlying medical and social factors.

**Clear and specific decision support and messaging for care teams.** Covid-related education, resources, and care can vary depending on underlying conditions and social needs. Accompany the lists of high- and moderate-risk members with condition-specific Covid-19 safety and education guidance to ensure clinical teams have the information needed to appropriately care for members. For example, Covid-related outreach calls are a key opportunity to ensure that members have health agents identified on health care proxy forms and, as appropriate, to initiate conversations about goals of care.

**Moving Forward**

The risk model can help other provider groups and hospital systems proactively identify their patients at the highest risk of serious morbidity or mortality from Covid-19. The model is simple to understand. It can help providers prioritize proactive outreach and monitoring to keep patients safe and at home, and allow for rapid care escalation, including in-home care if needed. The model may be helpful for economic projections and ensuring equitable resource distribution based on estimated needs. For hospital-based systems and providers, the model might be useful to help forecast hospitals’ needs and potential hospital bed shortages; insurers might use the model to
estimate likely hospitalization and ICU use among their membership. Insurers and providers with regional or citywide coverage can employ the model to estimate community-specific incidence of likely hospitalizations based on the underlying comorbidity burden of their populations and infection rates, and they can equitably distribute care and resourcing according to likely need. If combined with demographic data such as race/ethnicity and insurance type, the model can help researchers and policy makers identify socioeconomic and racial inequities in the risk of adverse outcomes for the Covid-positive population.

The model will be updated in the coming weeks as the global medical and public health communities learn more about the disease and disease risk factors, and we hope our risk tool can contribute to this global knowledge base. We strongly encourage other organizations, even those who typically commercialize risk-identification and analytic tools, to do the same. We will make efforts to update the code set and NDC codes as our shared learning continues to evolve (Appendix). If users of our model find value and adapt it further, we ask that they share that information with the corresponding author (ASM) so that we may keep running notes of additional use cases and insights. Despite the evolving evidence, the current model has given us crucial information to target our highest-risk members and support their medical and social needs during a period of escalating vulnerability.

Alina S. Schnake-Mahl, ScD, MPH  
Lead Research Scientist, Cityblock Health

Marcy G. Carty, MD, MPH  
Associate Chief Health Officer, Cityblock Health

Gerardo Sierra, MA  
Principal, Medical Economics and Quantitative Insights, and Actuary, Cityblock Health

Toyin Ajayi, MD, MPhil  
Chief Health Officer and Cofounder, Cityblock Health

Disclosures: Alina S. Schnake-Mahl, Marcy G. Carty, Gerardo Sierra, and Toyin Ajayi are all employees of Cityblock Health.

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