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Predicting 30 – Day outcomes in emergency department patients discharged with COVID-19

Benjamin McKay, MSIV [a], Matthew Meyers, MD [b], Leah Rivard, MD [b], Jill Stoltzfus, PhD [b], Guhan Rammohan, MD [b], Holly Stankewicz, DO [b,*]

[a] Temple/St. Luke's Medical School, 801 Ostrum Street, Bethlehem, PA 18015, United States
[b] St. Luke's University Health Network, 801 Ostrum Street, Bethlehem, PA 18015, United States

A R T I C L E I N F O

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A B S T R A C T

Introduction: Determining disposition for COVID-19 patients can be difficult for emergency medicine clinicians. Previous studies have demonstrated risk factors which predict severe infection and mortality however little is known about which risk factors are associated with failure of outpatient management and subsequent admission for COVID-19 patients.
Methods: We conducted a retrospective observational chart review of patients who had a confirmed positive COVID-19 test collected during an ED visit between March 1, 2020 and October 11, 2020. Patients were divided into two groups based on presence or absence of a subsequent 30-day hospitalization. Clinical and demographic information were collected including chief complaint, triage vital signs and comorbid medical conditions.
Results: 1038 patients were seen and discharged from a network ED with a positive SARS-CoV-2 PCR test. 94 patients (9.1%) were admitted to a hospital within 30 days of the index ED visit while 944 (90.9%) were not admitted to a network hospital within 30 days. Patients that were admitted were more likely to be older (aOR = 1.04 (95% CI 1.03–1.06)), hypoxic (aOR = 2.16 (95% CI 1.14–4.10)) and tachycardic (aOR = 2.13 (95% CI 1.34–3.38)) on initial ED presentation. Preexisting hypertension, diabetes mellitus, coronary artery disease, chronic kidney disease and malignancy were all highly significant risk factors for 30-day hospital admission following initial ED discharge ($p < 0.0001$).
Conclusion: Emergency Department providers should consider age, chief complaint, vital signs and comorbid medical conditions when determining disposition for patients diagnosed with COVID-19.

1. Introduction

The Coronavirus Disease 2019 (COVID-19) pandemic brought many uncertainties, including to the field of emergency medicine which served as the front-line for COVID-19 positive patients. On initial presentation to the emergency department (ED) with COVID-19 symptoms, patients requiring supplemental oxygen or mechanical ventilation provided an obvious disposition. For patients with concerning symptoms or other risk factors that do not present with hypoxia, their disposition is unclear. More informed assessment concerning the risk of bounce back and future hospitalization would help the emergency provider (EP) distinguish patients who can be safely discharged from those who require closer follow up, observation or admission. Prior studies have revealed that increasing age itself is a significant risk factor for severe COVID-19 manifestations and hospitalizations [1]. Elevated sequential organ failure assessment (SOFA) score or d-dimer and increased age were found to be risk factors for in-hospital death [2,3]. Initial data from a retrospective cohort of patients in Wuhan, China, where the pandemic originated, found increasing age to be an independent risk factor for development of acute respiratory distress syndrome (ARDS) and death [4]. One study out of the United States looking at greater than 800 admissions for COVID-19 in a single hospital system identified a median patient age of 64 with 21% being nursing home patients. Another case series of 5400 patients showed a median age of 63 for hospitalized patients [5,6]. While it is not surprising that increasing age leads to more morbidity and mortality for these patients, understanding the degree to which age affects prognosis can most certainly help determine disposition. Qualifying other risk factors for future deterioration besides age, which may be the most obvious and somewhat intuitive for an experienced EP, would be extremely useful in daily practice when caring for COVID-19 patients.

* Corresponding author.
E-mail addresses: tug39112@temple.edu (B. McKay), Matthew.meyers@sluhn.org (M. Meyers), leah.rivard@sluhn.org (L. Rivard), Jill.stoltzfus@sluhn.org (J. Stoltzfus), Guhan.rammohan@sluhn.org (G. Rammohan), holly.stankewicz@sluhn.org (H. Stankewicz).

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The objective of the present study is to determine what patient demographics and characteristics at ED presentation predict future deterioration and hospitalization. We hypothesized that the occurrence of 30-day admission following ED discharge is more likely in patients who had certain risk factors, chief complaints, and vital signs. Specifically, we predicted based on existing evidence that elderly patients would have higher 30-day admission rates than younger patients. We also predicted that those with the chief complaint of shortness of breath would have higher 30-day admission rates compared to those who did not complain of shortness of breath. Lastly, we predicted that patients who were tachycardic or tachypneic in triage or patients who had a recorded oxygen saturation of less than or equal to 94% at any point during the initial ED encounter would have higher rates of admission following ED discharge compared to those who were not tachycardic, tachypneic or hypoxic by those definitions.As a secondary outcome, we assessed ED discharge with 30-day revisit versus no 30-day revisit, not separated by subsequent hospital admission.

2. Methods

This IRB-approved study was conducted using a retrospective observational chart review without any patient interventions. Data were collected from a large healthcare network comprised of 12 hospitals in eastern Pennsylvania and western New Jersey which saw approximately 400,000 E.D. visits in FY2019 across approximately 270 network E.D. beds. There are approximately 1600 inpatient beds across the network. In the same geographic footprint, there is one other major hospital system whose data was not collected or analyzed in this study. Informed consent was waived due to the retrospective nature of this study. Comprehensive chart review was conducted using the Electronic Medical Record (EMR) provided by the study hospital. Patients were identified via the EMR as having a confirmed positive SARS-CoV-2 PCR test result that was ordered from an ED within the hospital network between March 1, 2020 and October 11, 2020. Patients were divided in a binary fashion depending on the presence or absence of a 30-day hospital admission. The patients who were not admitted within 30 days of ED discharge were then also subdivided into two groups: patients who returned to a network ED for any reason withing 30 days of ED discharge and those who did not. These charts were identified and selected for further review.

Inclusion criteria were all adult patients who had an ED visit with a subsequent confirmed positive SARS-CoV-2 polymerase chain reaction (PCR) test from the same encounter within the hospital network between March 1, 2020 and October 11, 2020. Exclusion criteria were patients under the age of 18, patients that tested positive for SARS-CoV-2 at other facilities or institutions and patients who may have had symptoms suspicious for COVID-19 but had a negative SARS-CoV-2 PCR test result.

There was a single extractor for the entire data set eliminating the potential for interrater variability. The extractor was trained via a formal training process. No data extractor forms were used, but as data were extracted from the EMR they were collated into a secure electronic database spreadsheet stored on a secure password-protected server. The abstractor was not blinded to the hypothesis and study objectives.

Demographic characteristics and vital signs were recorded as reported in the EMR (EPIC). Age was calculated as an integer from the day of their index ED visit in which they tested positive for SARS-CoV-2 virus. Age was recorded and analyzed as a continuous variable instead of being converted to a fixed categorical variable. Race was self-reported by the patient at the time of their registration into the EMR. When the race demographic was missing from the chart due to the patient's wish to non-identify or specify the race was recorded as "other" which fell into the "non-white" category. For simplicity of comparison certain quantitative variables collected via the EMR were converted to binary variables. For instance, BMI was automatically calculated based on the patient's weight on the day of their index ED visit and binarily classified as either obese or not obese using a BMI ≥ 30.0 to delineate the categories. When BMI was missing from the chart, non-obese was the default. Similarly, vital signs were classified in a binary fashion as either tachycardic or not tachycardic (defined as ≥100 beats per minute), tachypnea or not tachypnea (defined as RR ≥ 22), febrile or afebrile (defined as temperature ≥ 100.4° F), and hypoxia or no hypoxia (defined as SpO2 ≤ 94%). For standard of comparison, all vital signs used in this study were taken in triage except for the lowest recorded oxygen saturation which could have been taken at any point during the patient's index ED encounter. A more comprehensive chart review was performed looking for the lowest recorded oxygen saturation on the date of index ED encounter. For this variable, we looked for and included ambulatory pulse oximetry readings, if present, if they were part of the official documentation.

Subjective information was also obtained from the EMR relating to the patient's chief complaint and medical history. Many patients had more than one chief complaint and conversely some had chief complaints that were unrelated to the categories used in the study. In this scenario the chief complaint is not reflected in the results below. A patient was only marked as having a categorical chief complaint if it was clear and obvious from the documentation that they were complaining of those symptoms. For instance, a patient with a chief complaint of "I can't walk without having to stop to catch my breath" would be categorized as having a chief complaint of 'shortness of breath', but not 'weakness'. Similarly, the patient's comorbidities were only documented if it was clear in the patient's chart that they had received a prior diagnosis of the condition in question. Only comorbidities that were present at the time of the index ED encounter were recorded in the data set. For the malignancy comorbidity, any patient with a prior diagnosis of cancer was considered as having the comorbidity even if the cancer was in remission. Immunosuppression was defined as any patient with chronic immunosuppressive disease or any patient who was taking immunosuppressive drugs such as high dose steroids, chemotherapy, methotrexate or tacrolimus at the time of their index ED encounter. For the purposes of this study, comorbid conditions were looked at on an individual basis and not cumulatively.

2.1. Data analysis

For our primary outcome, ED discharge with 30-day revisit and subsequent hospital admission, we constructed a multivariable direct logistic regression model using demographic and clinical variables that were significantly different between groups based on separate chi square tests for categorical variables and an independent samples *t*-test for age as a normally distributed continuous variable. Given our somewhat limited event rate for our primary outcome, we used a more conservative alpha value of 0.05 for regression modeling purposes, which allowed us to remain as close as possible to the commonly accepted "rule of thumb" of at least 10 events per covariate for sample size purposes [7]. Prior to modeling, we confirmed linearity in the logit for age, based on examination of the predicted probability and raw residual scatterplots. We further confirmed absence of substantial outliers and influential data points based on examination of normalized residuals, Cook's D, and leverage statistics. To ascertain model goodness of fit, we reported the omnibus chi square and Hosmer Lemeshow goodness-of- fit statistic. For each covariate, we reported adjusted odds ratios (aORs) and 95% confidence intervals (CIs).

For our secondary outcome, ED discharge with 30-day revisit (not separated by subsequent hospital admission), we conducted separate chi square and independent samples *t*-tests, as appropriate. We used SPSS version 27 to analyze our data (Armonk, NY: IBM Corp.), with $p < 0.05$ denoting statistical significance, and no adjustment for the multiple comparisons.

3. Results

There were 1038 patients who were seen and discharged from a network ED with a positive SARS-CoV-2 PCR test during the specified time period. Of this group, 94 patients (9.1%) subsequently returned to a network ED and were ultimately admitted to a network hospital within 30 days of the index ED (Admitted after ED discharge group). 944 of the initial 1038 patients (90.9%) were not admitted to a network hospital at any point within the 30 days following initial ED evaluation (No hospital admission within 30 days).

Table 1 presents demographic and clinical variables for patients with subsequent hospital admission following ED revisit versus patients with no subsequent admission. Statistically significant bivariate comparisons between the two groups included age ($p < 0.0001$), White versus non-White race ($p = 0.002$), tachycardia ($p = 0.01$), tachypnea ($p = 0.001$), hypoxic during triage ($p < 0.0001$), hypoxic during any point in the ED encounter ($p < 0.0001$), shortness of breath ($p = 0.01$), chest pain ($p < 0.0001$), weakness ($p < 0.0001$), hypertension ($p < 0.0001$), diabetes ($p < 0.0001$), coronary artery disease ($p < 0.0001$), chronic heart failure ($p < 0.0001$), chronic kidney disease ($p < 0.0001$), and malignancy ($p < 0.0001$). To reduce the likelihood of multicollinearity, we included coronary artery disease and not chronic heart failure, as well as hypoxic during any point in the ED encounter and not hypoxic during triage. This resulted in 13 covariates for inclusion in our regression model.

Table 2 presents the multivariable regression model results. The model demonstrated adequate fit (omnibus chi square $p < 0.001$, Hosmer-Lemeshow $p = 0.25$), with a 91.6% correct rate of classification. Covariates associated with significantly greater likelihood of subsequent hospital admission following ED revisit included age ($p = 0.007$), tachycardia ($p = 0.003$), hypoxia during ED visit ($p = 0.002$), chest pain ($p = 0.001$), weakness ($p = 0.03$), diabetes ($p < 0.001$), and chronic kidney disease ($p < 0.001$).

Table 3 presents demographic and clinical variable comparisons for our secondary outcome, ED revisits within 30 days of patients' index ED encounter (revisit group) versus patients who did not return to a network ED within 30 days (non-revisit group). Patients in the revisit group were more likely to be older ($p < 0.0001$) and have a prior diagnosis of diabetes mellitus, chronic kidney disease, or malignancy ($p \le 0.0001$). Additionally, hypoxia occurred in 39/254 (15.4%) revisit patients versus 77/784 (9.8%) in non-revisit patients ($p = 0.02$).

Table 2
Multivariable logistic regression for ED revisit with subsequent hospital admission.

Covariate	Adjusted odds ratio (95% confidence interval)	*p*-Value
Age	1.02 (1.01–1.04)	0.007
Tachycardia	2.12 (1.29–3.51)	0.003
Hypoxic during ED visit	2.25 (1.26–4.01)	0.002
Chest pain	3.17 (1.56–6.47)	0.001
Weakness	2.45 (1.08–5.54)	0.03
Diabetes	2.85 (1.64–4.93)	<0.001
Chronic kidney disease	6.65 (2.45–18.00)	<0.001

4. Discussion

In the early months of the COVID-19 pandemic there was tremendous uncertainty in Emergency Departments around the country about how to treat and disposition patients with mild COVID-19 infections. As the pandemic continued, there was a lot of fear about unknown sequela and reports of COVID-related exacerbations of comorbid conditions that continued to muddy the waters about who could be safely discharged home with mild symptoms. This retrospective analysis of 30-day outcomes of COVID-19 patients confirms that like many other conditions that present to the Emergency Department, when determining the disposition of COVID-19 patients physicians should consider the patient's age, comorbidities, and vital sign abnormalities. Through the data we were able to confirm previously published studies identifying advanced age as a risk factor for hospitalization [8]. This study further delineated which abnormal vital signs, and at which thresholds those vital signs, affected disposition. For example, hypoxia is traditionally defined as an O2 saturation of ≤92%, however in our study we demonstrated a significant difference in the likelihood of a patient to return to the ED and subsequently be admitted to the hospital if their O2 saturation was ≤94%. Physicians can utilize this data not only to confirm

Table 1
Demographic and clinical variables for patients with subsequent hospital admission following ED revisit versus patients with no subsequent admission.

	ED discharge with 30-day revisit and subsequent hospital admission (n = 94)	ED discharge with 30-day revisit and no admission + ED discharge without 30-day revisit (n = 944)	*p*-Value[a]
Age (mean ± standard deviation)	56.2 years ± 16.9	43.4 years ± 16.4	<0.0001
Gender (n, %)	Female: 41 (43.6%)	Female: 482 (51.1%)	0.17
	Male: 53 (56.4%)	Male: 462 (48.9%)	
Race (n, %)	White: 56 (59.6%)	White: 407 (43.1%)	0.002
	Non-White: 38 (40.4%)	Non-White: 537 (56.9%)	
Smoking status (n, %)	Never or Unknown: 65 (69.1%)	Never or Unknown: 677 (71.7%)	0.002
	Former: 27 (28.7%)	Former: 166 (17.6%)	
	Current: 2 (2.1%)	Current: 101 (10.7%)	
Obesity (BMI ≥ 30) (n, %)	54/94 (57.4%)	471/944 (49.9%)	0.16
Tachycardic (HR ≥ 100) (n, %)	40/94 (42.6%)	283/944 (30%)	0.01
Febrile (temp ≥ 100.4) (n, %)	16/94 (17%)	114/944 (12.1%)	0.17
Tachypnic (RR ≥ 22) (n, %)	14/94 (14.9%)	58/944 (6.1%)	0.001
Hypoxic in Triage (SpO2 ≤ 94) (n, %)	17/94 (18.1%)	49/944 (5.2%)	<0.0001
Hypoxic during ED visit (SpO2 ≤ 94 at any point during encounter) (n, %)	31/94 (33%)	85/944 (9%)	<0.0001
Shortness of breath (n, %)	30/94 (31.9%)	197/944 (20.9%)	0.01
Chest pain (n, %)	14/94 (14.9%)	55/944 (5.8%)	<0.0001
Fever (n, %)	45/94 (47.9%)	427/944 (45.2%)	0.62
Weakness (n, %)	12/94 (12.8%)	41/944 (4.3%)	<0.0001
Abdominal pain (n, %)	4/94 (4.3%)	45/944 (4.8%)	0.82
Hypertension (n, %)	42/94 (44.7%)	233/944 (23.6%)	<0.0001
Diabetes (n, %)	35/94 (37.2%)	115/944 (12.2%)	<0.0001
Coronary artery disease (n, %)	11/94 (11.7%)	31/944 (3.3%)	<0.0001
Chronic heart failure (n, %)	5/94 (5.3%)	11/944 (1.2%)	0.002
COPD or asthma (n, %)	18/94 (19.1%)	145/944 (15.4%)	0.34
Chronic kidney disease (n, %)	13/94 (13.8%)	13/944 (1.4%)	<0.0001
Malignancy (n, %)	10/94 (10.6%)	27/944 (2.9%)	<0.0001
Immunosuppression (n, %)	3/94 (3.2%)	14/944 (1.5%)	0.21

[a] Based on separate independent samples t-tests or chi square tests, as appropriate.

Table 3
Secondary outcomes.

	ED discharge with 30-day revisit (n = 254)	ED discharge with no 30-day revisit (n = 784)	p-Value[a]
Age (mean ± standard deviation)	48.3 years ± 17.1	43.4 years ± 16.5	<0.0001
Gender (n, %)	Female: 138 (54.3%) Male: 116 (45.7%)	Female: 385 (49.1%) Male: 399 (50.9%)	0.15
Race (n, %)	White: 125 (49.2%) Non-White: 129 (50.8%)	White: 338 (43.1%) Non-White: 446 (56.9%)	0.09
Smoking status (n, %)	Never or Unknown: 177 (69.7%) Former: 63 (24.8%) Current: 14 (5.5%)	Never or Unknown: 565 (72.1%) Former: 130 (16.6%) Current: 89 (11.4%)	0.001
Obesity (BMI ≥ 30) (n, %)	135/254 (53.1%)	390/784 (49.7%)	0.35
Tachycardic (HR ≥ 100) (n, %)	87/254 (34.3%)	236/784 (30.1%)	0.21
Febrile (temp ≥ 100.4) (n, %)	32/254 (12.6%)	98/784 (12.5%)	0.97
Tachypnic (RR ≥ 22) (n, %)	24/254 (9.4%)	48/784 (6.1%)	0.07
Hypoxic in Triage (SpO2 ≤ 94) (n, %)	18/254 (7.1%)	48/784 (6.1%)	0.58
Hypoxic during ED Visit (SpO2 ≤ 94 at any point during encounter) (n, %)	39/254 (15.4%)	77/784 (9.8%)	0.02
Shortness of breath (n, %)	68/254 (26.8%)	159/784 (20.3%)	0.03
Chest pain (n, %)	25/254 (9.8%)	44/784 (5.6%)	0.02
Fever (n, %)	117/254 (46.1%)	355/784 (45.3%)	0.83
Weakness (n, %)	18/254 (7.1%)	35/784 (4.5%)	0.10
Abdominal pain (n, %)	14/254 (5.5%)	35/784 (4.5%)	0.49
Hypertension (n, %)	79/254 (31.1%)	186/784 (23.7%)	0.02
Diabetes (n, %)	62/254 (24.4%)	88/784 (11.2%)	<0.0001
Coronary artery disease (n, %)	16/254 (6.3%)	26/784 (3.3%)	0.04
Chronic heart failure (n, %)	6/254 (2.4%)	10/784 (1.3%)	0.22
COPD or asthma (n, %)	52/254 (20.5%)	111/784 (14.2%)	0.02
Chronic kidney disease (n, %)	15/254 (5.9%)	11/784 (1.4%)	< 0.0001
Malignancy (n, %)	18/254 (7.1%)	19/784 (2.4%)	< 0.0001
Immunosuppression (n, %)	5/254 (2%)	12/784 (1.5%)	0.63

[a] Based on separate independent samples t-tests or chi square tests, as appropriate.

their disposition gestalt for COVID-19 patients, but also to include patients in the shared decision-making process of the risks and benefits of admission versus close outpatient follow-up for mild to moderate COVID-19 infections.

Previously published guidelines have utilized objective data such as blood oxygen saturation, heart rate, and respiratory rate to determine disposition of COVID-19 patients in the emergency department [14]. Subjective dyspnea has been associated with a higher likelihood of hospital admission when comparing symptoms in hospitalized and non-hospitalized COVID-19 patients [15]. These data support this logic as patients with tachycardia, tachypnea, or a blood oxygen saturation ≤ 94% portend failure of outpatient management and hospital admission.

These data also suggest that preexisting conditions should be considered when determining disposition. Previously studies have demonstrated as much as 12 times greater mortality in COVID-19 patients with co-morbid medical conditions compared to COVID-19 patients without preexisting medical conditions [16]. Hypertension, diabetes mellitus, coronary artery disease, chronic kidney disease and history of malignancy were all significantly more prevalent in patients admitted to the hospital within 30 days of initial ED visit. Hypertension, diabetes mellitus, coronary artery disease, COPD, chronic kidney disease and malignancy were also significantly associated with higher rate of ED return visit when compared to patients who did not return to the ED within 30 days. In patients with these preexisting conditions, ED providers should take care to ensure that disease course is monitored by a primary care provider.

Outpatient management targeted against COVID-19 continues to evolve [17]. In particular, monoclonal antibody infusion has become widely available and is now frequently utilized in select patients diagnosed with COVID-19 [18,19]. These therapeutics are administered with the goal of preventing disease progression and now are utilized in the outpatient setting for moderate COVID-19 disease to prevent subsequent hospitalization. Many of these treatment options were not available during the period of data collection. These data may not be reproducible if the outpatient management of COVID-19 continues to successfully halt disease progression and hospital admissions.

4.1. Limitations

This study does have some limitations. First, our retrospective chart review does not include unmeasured contributing and confounding variables that may have impacted our findings. Second, if the patient tested positive at the study hospital but followed up at another hospital outside of the study network, they would not have been included in the study. Additionally, if the patient tested positive at an outside hospital and followed up at the study hospital, they would not have been included in the study either. It is possible that the absolute lowest oxygen saturation as measured by pulse oximetry may not have been documented in the chart of every patient. The documented temperatures may not have all been true core temperatures. The recorded body weights of each patient may not have been accurate as some are self-reported and others were measured in the ED, however given the binary reporting of data this is less likely to be a major limitation. The abstractor of the study data was not blinded to the study hypothesis. While this could have led to bias, an effort was made to limit the types of data being abstracted to objective data points. Unlike many other studies, the results of our study did not show a significant difference between the admission rates of immunosuppressed patients and those who were not immunosuppressed. This aberrance could certainly represent a type II error or possibly a difference in the types of immunosuppressed patients that were seen within the network being studied. Another limitation to this study is that there were missing data points in certain categories. For instance, 21 out of the 1038 patients had either no weight or height recorded in their chart to calculate BMI. For these patients, they were added to the non-obese category for data analysis purposes. Similarly 12 of the 1038 patients chose not to disclose their race. For data analysis purposes these patients were listed as “non-white”. 6 of 1038 had no temperature recorded and were categorized as “afebrile”. Lastly, since the data was collected over a period when much was unknown and changing in the treatment and evaluation of patients with COVID-19, it is unknown if these changing protocols may have played a role in the disposition decisions and their potential return visits.

4.2. Conclusion

In reviewing 1038 patients diagnosed with COVID-19 during an ED visit between March and October of 2020, we found that advanced age, presence of hypoxia or tachycardia during initial ED evaluation were significantly associated with 30-day hospital admission. Preexisting hypertension, diabetes mellitus, coronary artery disease, chronic kidney disease and malignancy were all highly significant risk factors for 30-day hospital admission following initial ED discharge. Emergency Department providers should consider patient age, chief complaint, vital signs and comorbid medical conditions when determining disposition for patients diagnosed with COVID-19.

Author contributions

Benjamin McKay contributed in conceptualization, data curation, investigation, methodology, writing-original draft, writing-review and editing. Matthew Meyers contributed in conceptualization, methodology, writing-original draft, writing-review and editing. Leah Rivard contributed in writing-original draft and writing-review and editing. Jill Stoltzfus contributed in formal analysis, methodology, validation, writing-original draft, writing-review and editing. Guhan Rammohan contributed in conceptualization, methodology, supervision, writing-original draft, writing-review and editing. Holly Stankewicz contributed in conceptualization, methodology, supervision, writing-original draft, writing-review and editing.

Declaration of Competing Interest

None.

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