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A prediction model of risk factors for complications among SARS-CoV2 positive patients: Cases from Jordan

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ABSTRACT

Background: The number of COVID-19 infected patients has been soaring in the Middle East countries. The disease poses a significant threat, decisions about prioritizing care should be made in accordance with the proven risk factors for complications.

Objective: The present study provides the first bespoke prediction model in the Middle East to identify COVID-19 patients, who are at higher risk for complications.

Method: A case-control study design was adopted to compare the characteristics of successfully recovered patients with those who had complications. Complications were defined as admission to the intensive care unit, mechanical ventilation, sepsis or septic shock, pneumonia or respiratory failure, and death. The prediction model was created through multivariable logistic regression. Overall statistical significance tests for the model were carried out.

Results: All COVID-19 infected hospitalized patients (n = 133) in Amman – Jordan were included in the study. Successfully recovered were 125 patients. The median age (IRQ) was 26 (10–40). Almost 30% were >40 years. Patients with complications were eight patients, age 63 (51.5–71.5). The prediction model identified the following variables as risk factors: diabetes (OR = 59.7; 95% CI: 3.5–1011.5, p = 0.005), fever (OR = 24.8; 95% CI: 1.4–447.3, p = 0.029), SHORTNESS OF BREATH (OR = 15.9; 95% CI: 1.3–189.7, p = 0.029), body mass index (OR = 0.74; 95% CI: 0.61–0.88, p = 0.001), abnormal Neutrophils (OR = 16.8; 95% CI: 1.0–292.0, p = 0.053). Prediction model was statistically significant, \( \chi^2(5) = 86.1, p < 0.0005 \).

Conclusions: Unlike reports from China, the most influential variables that led to disease progression in Jordanian patients were diabetes, fever, shortness of breath, body mass index, and abnormal neutrophils. Similar to reports from the USA, smoking was not a leading factor for complications. Comorbidities and patient health status, rather than age, were the primary risk factors for complications. Treatment with Hydroxychloroquine showed no protective effect.

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Introduction

In late December 2019, patients in Wuhan, China began experiencing symptoms of pneumonia brought on by a coronavirus. Initially was called the 2019 novel coronavirus (2019-nCoV). Once the gene for the virus was sequenced, scientists found that the new virus shared 79.5% of its genome with SARS-CoV [1]. It was then renamed the “Severe Acute Respiratory Syndrome-Coronavirus2 SARS-CoV-2” [1, 2].

By February 2020, the virus started spreading outside China. On March 11th, 2020, it was declared a pandemic by the World Health Organization [3]. The virus infected almost 3 million people and caused 230 thousand death by April 30th, 2020 [4].

The majority of patients with COVID-19, the disease caused by the SARS-CoV-2 virus, were asymptomatic or showed mild symptoms of the disease [5, 6]. Approximately 20% of the infected
patients were admitted to ICU, due to severity of illness and complication. Unfortunately, cases of death were reported as well [6]. In Italy, about 9% of patients who tested positive for the SARS-CoV2 virus were transferred to the ICU. Whereas in China, the ICU was needed for 5–32% of COVID-19 hospitalized patients [7–9].

Old age, male sex, hypertension, diabetes, and cardiovascular disease were identified as risk factors associated with both ICU admission and subsequent death [5,7,10–12]. Elevated D-Dimer and lymphopenia were also associated with worse prognosis [11]. A recent study in the US found that hospitalized patients were more likely to be obese, male, having cardiovascular disease and diabetes compared with non-hospitalized patients, an early elevation in D-Dimer and CRP were also indicators of a more complicated course [13]. During triage, it is crucial to identify COVID-19 patients who are at higher risk for complications. Not only for better resource optimization but also for delivering tailored patients’ care.

The first case of COVID-19 in Jordan was reported on March 2nd, 2020, as of April 18th, 2020 there have been 413 cases of the SARS-CoV2 virus infection and 7 cases of death [14]. In Amman, the capital city of Jordan, Prince Hamza Hospital was designated to be the main hospital for COVID-19 infected patients. Such setup offered a unique opportunity to study and identify the risk factors for COVID-19 related complications. Moreover, it enabled us to create a prediction model to identify patients at higher risk for such complications.

Methods

Ethical approval

Ethical approvals were provided by Prince Hamza Hospital Internal Review Board (IRB) (Approval code: 2/1/1641) and the Hashemite University IRB (Approval code: 5/5/2019/2020).

Settings and participants

The study was conducted at Prince Hamza Hospital, the main hospital to screen and manage corona infections in the capital city of Jordan, Amman. Hospitalized patients with laboratory-confirmed coronavirus were included in the study. COVID-19 infection confirmation was based on results of real-time reverse transcriptase-polymerase-chain-reaction (RT-PCR) and the assay of nasopharyngeal (or oropharyngeal) swab specimens. Administrative, electronic health records, clinical, and laboratory data were collected for patients admitted between March 15, 2020, and April 6, 2020, with follow up through April 23rd, 2020.

Design

The case-control study design was adopted for the present study. Patients who had complications were considered the cases for the disease progression, while infected and recovered patients were the recovery group.

Evaluation of the cases

Patients who had any of the following criteria were considered within the progressed group: admission to ICU, having received mechanical ventilation, sepsis or septic shock, pneumonia or respiratory failure, and death. The following respiratory parameters were considered also within the complication: respiratory distress, RR ≥ 30 breaths/min; oxygen saturation <93% at rest; partial pressure of oxygen (PaO2)/fraction of inspired oxygen ≤300 mmHg. Patients who had been discharged without complications were considered the successfully recovered group.

Predictors and data collection

The following data was collected for each patient: gender and age, weight and height, body mass index (BMI) was calculated as weight/(height^2), smoking status. Comorbidities including hypertension, ischemic heart disease, diabetes, hyperlipidemia, hypothyroidism, gastroesophageal reflux disease (GERD), migraine, palpitations, chronic obstructive pulmonary disease (COPD), receiving hydroxychloroquine medication, were also considered. Data was collected for the following symptoms: cough (dry or wet), fever, chills and/or rigor, sweating, generalized malaise, myalgia, shortness of breath (SOB), headache, hemoptysis, diarrhea, chest pain, abdominal pain, palpitations, loss of taste, loss of smell, nasal congestion, rhinorrhea, and others like sneezing, conjunctivitis, sore throat, vomiting, gum and tooth pain, parasthesia. Data for the following lab tests results were collected, hemoglobin (Hb), hematocrit (HTC), weight blood cells (WBC), neutrophils, lymphocytes, basophils, monocytes, eosinophils, platelets, C-reactive protein, urea, creatinine in serum, sodium, potassium, bilirubin (total), bilirubin (direct – conjugated), aspartate aminotransferase (AST) and alanine aminotransferase (ALT), prothrombin time (PT), international normalized ratio (INR) and D-Dimer.

Statistical analysis

Descriptive statistics were presented for all recruited patients. Data for patients older than 20 years were compared between the recovery and progress group. To carry out univariate analysis, continuous variables were analyzed using the Mann–Whitney U test. Categorical variables were analyzed using the Chi-squared test or Fisher’s exact test. Freeman–Halton extension of the Fisher exact probability test was carried out for a two-rows by three-columns contingency table. The odds ratio along with the 95% confidence interval (CI) for each predictor was also calculated. Statistically significant value for each predictor was presented. Due to sample size, only eight predictors were selected to be transferred to the multivariable regression model. Predictors that demonstrated statistically significant differences between the groups were considered for further analysis, as a risk factor for progression. With consideration to prior published literature and the clinical experience with COVID-19 patients, the top eight predictors were selected for the process of stepwise, backward regression. For evaluating the quality of the logistic regression results (i.e., model fit), overall statistical significance tests for models were carried out. The Omnibus Test of Model Coefficients [15] was used to measure how well the final model predicted categories compared to the baseline model and other previous models in the backward stepwise approach (i.e. p-value for the final model should be <0.05). The Hosmer and Lemeshow goodness of fit test [16] was used to assess how good the model was at predicting the categorical outcomes (i.e. a good model has p > 0.05 and a poorly fitting model has significant p-value). All data were managed and analyzed by using SPSS version 26.

Results

Between March 15th and April 6th, 2020, A total of 133 patients were admitted to Prince Hamza hospital in Amman, Jordan, and recruited in this study. A visual summary is shown in Fig. 1, which illustrates that 125 patients have successfully recovered. Table 1 summarizes the demographic variables. The median age was 26 years (interquartile range 10–40 years), 24.2% were less than 20 years old, and 30% were over 40 years of age. There were only eight patients who had medical complications; their median age was 63 years (51.5–71.5 years).
Table 1
Demographic and comorbidities characteristics of patients diagnosed with SARS-CoV-2 and recovered successfully without complications.

| Category | Infected and recovered, control group (n = 72) | Infected and complication, exposed group (n = 8) | p Value (Fisher’s exact test) | Odds ratio (95% confidence interval) | p Value of the odds ratio |
|----------|-----------------------------------------------|-----------------------------------------------|------------------------------|-----------------------------------|--------------------------|
| Gender   |                                               |                                               |                              |                                   |                          |
| Female   | 40                                            | 2                                             | 0.14                         | 3.750                             | 0.708; 19.850; 0.12     |
| Male     | 32                                            | 6                                             |                              |                                   |                          |
| Age subgroup |                                    |                                               |                              |                                   |                          |
| >20 and <60 | 67                                            | 3                                             | 0.0005                       | 22.33                             | 4.0986; 121.6951; 0.0003|
| >61      | 5                                             | 5                                             |                              |                                   |                          |
| Age subgroups |                                |                                               |                              |                                   |                          |
| >40 and <60 | 25                                            | 3                                             | 0.019                         | 8.33                              | 1.5; 46.7; 0.016        |
| >61      | 5                                             | 5                                             |                              |                                   |                          |
| Body mass index |                            |                                               |                              |                                   |                          |
| <30      | 58                                            | 1                                             | 0.0002                       | 29.000                            | 3.2943; 255.2874; 0.002 |
| >30      | 14                                            | 7                                             |                              |                                   |                          |
| Smoking  |                                               |                                               |                              |                                   |                          |
| Non smoker | 45                                            | 6                                             | 0.70                         | 0.556                             | 0.105; 2.951; 0.49     |
| Smoker   | 27                                            | 2                                             |                              |                                   |                          |
| Hypertension (HTN) |                         |                                               |                              |                                   |                          |
| No HTN   | 62                                            | 6                                             | 0.34                         | 2.067                             | 0.365; 11.705; 0.41    |
| HTN      | 10                                            | 2                                             |                              |                                   |                          |
| Diabetes |                                               |                                               |                              |                                   |                          |
| No diabetes | 65                                            | 2                                             | 0.0001                       | 27.857                            | 4.697; 165.210; 0.0002 |
| Diabetes | 7                                             | 6                                             |                              |                                   |                          |
| Ischemic heart disease |                       |                                               |                              |                                   |                          |
| No       | 70                                            | 7                                             | 0.27                         | 5.000                             | 0.401; 62.334; 0.21    |
| Yes      | 2                                             | 1                                             |                              |                                   |                          |
| COPD     |                                               |                                               |                              |                                   |                          |
| No       | 71                                            | 8                                             | 1                            | 2.8039                            | 0.1056; 74.4204; 0.537 |
| Yes      | 1                                             | 0                                             |                              |                                   |                          |
| Hyperlipidaemia |                          |                                               |                              |                                   |                          |
| No       | 70                                            | 6                                             | 0.048                        | 11.667                            | 1.387; 98.166; 0.024   |
| Yes      | 2                                             | 2                                             |                              |                                   |                          |
| Hypothyroid |                                 |                                               |                              |                                   |                          |
| No       | 69                                            | 7                                             | 0.35                         | 3.286                             | 0.300; 35.966; 0.33    |
| Yes      | 3                                             | 1                                             |                              |                                   |                          |
| Hydroxychloroquine, received medication |                  |                                               |                              |                                   |                          |
| No       | 24                                            | 1                                             | 0.42                         | 0.286                             | 0.0332; 2.4574; 0.25   |
| Yes      | 48                                            | 7                                             |                              |                                   |                          |

Numbers highlighted in bold indicate significant results.

The following factors demonstrated a statistically significant association with complications (Table 2): Age older than 40 years, p = 0.019 (odds ratio [OR] = 8.33; 95% CI: 1.5–46.7; p = 0.016), age older than 20 years, p = 0.0005 (OR = 22.33, 95% CI: 4.1–121.7; p = 0.0003). Moreover, statistical analysis results for patients older than 20 years revealed the following factors were significantly associated with complications: body mass index (BMI) > 30, p = 0.0002 (OR = 29.0; 95% CI: 3.3–255.3; p = 0.002), and diabetes, p = 0.0001 (OR = 27.9; 95% CI: 4.7–165.2; p = 0.0002). Descriptive results for clinical symptoms are illustrated in Table 3. The factors that had a
Table 3
Signs and symptoms for Patients diagnosed with SARS-CoV-2 and recovered successfully without complications.

|                      | All (%) | 0–12 years | 13–20 years | 21–40 years | 41–60 years | 61–75 years |
|----------------------|---------|------------|-------------|-------------|-------------|-------------|
| Fever                | 40 (32.0) | 4 (21.6) | 13 (8.3) | 18 (47.1) | 10 (40.0) | 5 (400.0) |
| Wet cough            | 27 (21.6) | 2 (5.6) | 1 (5.9) | 12 (28.6) | 8 (32.0) | 4 (80.0) |
| Chills/ rigors       | 48 (38.4) | 5 (13.9) | 9 (29.4) | 22 (52.4) | 14 (56.0) | 6 (80.0) |
| Headache             | 23 (18.4) | 0 (0.0) | 2 (11.8) | 12 (28.6) | 7 (28.0) | 2 (40.0) |
| Paraesthesia         | 58 (46.4) | 6 (16.7) | 11 (64.7) | 28 (66.7) | 12 (48.0) | 1 (20.0) |
| Palpitations         | 58 (46.4) | 6 (16.7) | 11 (64.7) | 28 (66.7) | 12 (48.0) | 1 (20.0) |
| Myalgia              | 48 (38.4) | 6 (16.7) | 11 (64.7) | 28 (66.7) | 12 (48.0) | 1 (20.0) |
| Cough                | 19 (15.2) | 6 (16.7) | 11 (64.7) | 28 (66.7) | 12 (48.0) | 1 (20.0) |
| Abdominal pain       | 25 (20.0) | 6 (16.7) | 11 (64.7) | 28 (66.7) | 12 (48.0) | 1 (20.0) |
| Palpitations         | 10 (8.0) | 6 (16.7) | 11 (64.7) | 28 (66.7) | 12 (48.0) | 1 (20.0) |
| Loss of sense        | 51 (40.8) | 8 (22.2) | 11 (64.7) | 26 (61.9) | 15 (60.0) | 1 (20.0) |
| Nausea               | 49 (39.2) | 6 (16.7) | 5 (29.4) | 27 (64.3) | 10 (40.0) | 1 (20.0) |
| Other                | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| Sneeze               | 2 (1.6) | 1 (2.8) | 0 (0.0) | 1 (2.4) | 0 (0.0) | 0 (0.0) |
| Conjunctivitis       | 2 (1.6) | 2 (5.6) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| Sore throat          | 3 (2.4) | 0 (0.0) | 1 (5.9) | 0 (0.0) | 2 (8.0) | 0 (0.0) |
| Vomiting             | 2 (1.6) | 0 (0.0) | 0 (0.0) | 2 (8.0) | 0 (0.0) | 0 (0.0) |
| Gums and teeth pain  | 1 (0.8) | 0 (0.0) | 0 (0.0) | 1 (2.4) | 0 (0.0) | 0 (0.0) |
| Paraesthesia         | 1 (0.8) | 0 (0.0) | 0 (0.0) | 1 (2.4) | 0 (0.0) | 0 (0.0) |

Table 4
Univariate analysis to compare signs and symptoms reported for recovered vs. patients admitted to ICU due to complications.

| Signs and symptoms          | Infected and recovered, control group (n = 72) | Infected and complication, exposed group (n = 8) | p Value (Fisher’s exact test) | Odds ratio (95% confidence interval) | p Value of the odds ratio |
|-----------------------------|-----------------------------------------------|-----------------------------------------------|--------------------------------|--------------------------------------|--------------------------|
| Asymptomatic                | 5                                             | 0                                             | 0.47                          | 0.72                                | 0.037                    | 14.230                   | 0.83                     |
| Dry cough                   | 33                                             | 5                                             | 0.25                          | 5.48                                | 0.0005                  | 1289.356                 | 0.012                    |
| Fever                       | 25                                             | 8                                             | 0.0005                        | 31.66                               | 1.755                   | 571.227                  | 0.019                    |
| Wet cough                   | 24                                             | 4                                             | 0.002                         | 31.66                               | 1.755                   | 571.227                  | 0.019                    |
| Chills/ rigors              | 38                                             | 4                                             | 0.002                         | 31.66                               | 1.755                   | 571.227                  | 0.019                    |
| Headache                    | 21                                             | 7                                             | 0.0001                        | 40.72                               | 2.249                   | 737.319                  | 0.012                    |
| Myalgia                     | 42                                             | 7                                             | 0.0001                        | 40.72                               | 2.249                   | 737.319                  | 0.012                    |
| Cough                       | 49                                             | 8                                             | 0.0001                        | 40.72                               | 2.249                   | 737.319                  | 0.012                    |
| Abdominal pain              | 43                                             | 0                                             | 0.0001                        | 40.72                               | 2.249                   | 737.319                  | 0.012                    |
| Nausea                      | 19                                             | 8                                             | 0.0001                        | 40.72                               | 2.249                   | 737.319                  | 0.012                    |
| Other                       | 0                                              | 0                                             | 0.0001                        | 40.72                               | 2.249                   | 737.319                  | 0.012                    |
| Sneeze                      | 2                                              | 0                                             | 0.0001                        | 40.72                               | 2.249                   | 737.319                  | 0.012                    |
| Conjunctivitis              | 6                                              | 0                                             | 0.0001                        | 40.72                               | 2.249                   | 737.319                  | 0.012                    |
| Sore throat                 | 1                                              | 0                                             | 0.0001                        | 40.72                               | 2.249                   | 737.319                  | 0.012                    |
| Vomiting                    | 0                                              | 0                                             | 0.0001                        | 40.72                               | 2.249                   | 737.319                  | 0.012                    |
| Gums and teeth pain         | 0                                              | 0                                             | 0.0001                        | 40.72                               | 2.249                   | 737.319                  | 0.012                    |
| Paraesthesia                | 0                                              | 0                                             | 0.0001                        | 40.72                               | 2.249                   | 737.319                  | 0.012                    |

Numbers highlighted in bold indicate significant results.

Fig. 1. Performance of patients diagnosed with SARS-CoV-2.

statistically significant association with complication were as follows (Table 4): fever, p = 0.0005 (OR = 31.66; 95% CI: 1.8–571.2; p = 0.019), sweating, p = 0.002 (OR = 17.0; 95% CI: 2.0–146.8; p = 0.010), myalgia, p = 0.007 (OR = 17.0; 95% CI: 1.0–305.5; p = 0.054), shortness of breath SOB, p = 0.0001 (OR = 40.7; 95% CI: 2.2–737.3; p = 0.012), hemoptysis, p = 0.009 (OR = 55.77; 95% CI: 2.4–1289.3; p = 0.012) and diarrhea, p = 0.006 (OR = 0.053; 95% CI: 0.0029–0.948; p = 0.046). Lab results showing association with complications were as follows (Table 5): an elevated neutrophil count, p = 0.007; a low lymphocyte count, p < 0.01; a low basophil count p = 0.043; a low potassium level, p = 0.02; elevated D-dimer, p = 0.005.

Prediction model: Four steps backward logistic regression model showed statistical significance, χ²(5) = 86.1, p < 0.0005. The model explained 88.0% (Nagelkerke R²) of the variance in dis-
Table 5

Univariate analysis to compare lab results for recovered patients to patients admitted to ICU due to complications (n = 80).

| Category/lab result | Infected and recovered, control group (n = 72) | Infected and complication, exposed group (n = 8) | p Value Freeman–Halton extension of the Fisher exact test |
|---------------------|-----------------------------------------------|-----------------------------------------------|---------------------------------------------------|
| HB                  |                                               |                                               |                                                   |
| Low <12 g/dL        | 1                                             | 10                                            |                                                   |
| Normal 12–16 g/dL   | 7                                             | 53                                            | 0.83                                              |
| High <16 g/dL       | 0                                             | 9                                             |                                                   |
| HCT                 |                                               |                                               |                                                   |
| Low <35%            | 1                                             | 7                                             |                                                   |
| Normal 35–47%       | 7                                             | 58                                            | 0.99                                              |
| High <47%           | 0                                             | 7                                             |                                                   |
| WBC                 |                                               |                                               |                                                   |
| Low <4000 μL        | 1                                             | 10                                            |                                                   |
| Normal 4000–11000 μL| 5                                             | 59                                            | 0.10                                              |
| High <11000 μL      | 2                                             | 3                                             |                                                   |
| Neutrophil%         |                                               |                                               |                                                   |
| Low <40%            | 0                                             |                                               |                                                   |
| Normal 40–80%       | 2                                             | 54                                            | 0.007                                              |
| High <80%           | 6                                             | 18                                            |                                                   |
| Lymphocyte%         |                                               |                                               |                                                   |
| Low <20%            | 6                                             | 5                                             |                                                   |
| Normal 20–40%       | 2                                             | 48                                            | 0.0001                                              |
| High <40%           | 0                                             | 19                                            |                                                   |
| Basophil%           |                                               |                                               |                                                   |
| Low <0.5%           | 8                                             | 40                                            |                                                   |
| Normal 0.5–1%       | 0                                             | 30                                            | 0.043                                              |
| High <1%            | 0                                             | 2                                             |                                                   |
| Monocyte%           |                                               |                                               |                                                   |
| Low <2%             | 1                                             | 0                                             |                                                   |
| Normal 2–10%        | 6                                             | 45                                            | 0.06                                              |
| High <10%           | 1                                             | 27                                            |                                                   |
| Eosinophil%         |                                               |                                               |                                                   |
| Low <1%             | 5                                             | 17                                            |                                                   |
| Normal 1–6%         | 3                                             | 40                                            | 0.054                                              |
| High <6%            | 0                                             | 15                                            |                                                   |
| Platelets count     |                                               |                                               |                                                   |
| Low <150,000 μL     | 0                                             | 9                                             |                                                   |
| Normal 150,000–450,000 μL | 8 | 63 | 0.59 |
| High <450,000 μL    | 0                                             | 0                                             |                                                   |
| C-reactive protein  |                                               |                                               |                                                   |
| Normal 0–5.0 mg/L   | 2                                             | 38                                            |                                                   |
| High <5.0 mg/L      | 6                                             | 34                                            | 0.26                                              |
| Urea                |                                               |                                               |                                                   |
| Low <2.86 mmol/L    | 1                                             | 4                                             |                                                   |
| Normal 2.86–8.2 mmol/L | 5 | 59 | 0.22 |
| High <8.2 mmol/L    | 2                                             | 9                                             |                                                   |
| Creatinine (serum)  |                                               |                                               |                                                   |
| Low <59 mmol/L      | 1                                             | 19                                            |                                                   |
| Normal 59–104 mmol/L| 6                                             | 43                                            | 0.86                                              |
| High <104 mmol/L    | 1                                             | 10                                            |                                                   |
| Sodium              |                                               |                                               |                                                   |
| Low <135 mmol/L     | 3                                             | 8                                             |                                                   |
| Normal 135–152 mmol/L | 5 | 64 | 0.07 |
| High <152 mmol/L    | 0                                             | 0                                             |                                                   |
| Potassium           |                                               |                                               |                                                   |
| Low <3.5 mmol/L     | 3                                             | 3                                             |                                                   |
| Normal 3.5–5.3 mmol/L | 5 | 67 | 0.020 |
| High <5.3 mmol/L    | 0                                             | 2                                             |                                                   |
| AST                 |                                               |                                               |                                                   |
| Normal ≤38 U/L      | 6                                             | 69                                            | 0.076                                              |
| High <38 U/L        | 2                                             | 3                                             |                                                   |
| ALT                 |                                               |                                               |                                                   |
| Normal ≤41 U/L      | 8                                             | 66                                            | 0.99                                              |
| High <41 U/L        | 0                                             | 6                                             |                                                   |
| D-Dimer             |                                               |                                               |                                                   |
| Normal <0.5 μg/ml   | 0                                             | 9                                             |                                                   |
| High <0.5 μg/ml     | 8                                             | 5                                             | 0.005                                              |
| NA                  | 0                                             | 58                                            |                                                   |
| Bilirubin (total)   |                                               |                                               |                                                   |
| Low <3.4            | 0                                             | 4                                             |                                                   |
| Normal 3.4–20.5     | 8                                             | 25                                            | 0.65                                              |
ease progression and correctly classified 96.3% of cases. Hosmer and Lemeshow test was not statistically significant (Step four, \( p = 0.275 \)), indicating that the model was not a poor fit. As seen in Table 6, regression model demonstrates the following risk factors as statistically significant predictors for complications: an increase in one unit of the categorical variables (i.e., being diabetic, having fever, SOB and abnormal neutrophil count) will increase the odds for progression to complication as follows: diabetes (OR = 59.7; 95% CI: 3.5–1011.5, \( p = 0.005 \)), fever (OR = 24.8; 95% CI: 1.4–447.3, \( p = 0.029 \)), SOB (OR = 15.9; 95% CI: 1.3–189.7, \( p = 0.029 \)), neutrophil count (OR = 16.8; 95% CI: 1.0–292.0, \( p = 0.053 \)). As odds ratio for BMI was less than 1 (OR = 0.74; 95% CI: 0.61–0.88, \( p = 0.001 \)). The following variables were excluded at step 4, despite being in step one: Myalgia, Age, Lymphocytes.

### Table 6

Logistic regression (stepwise, backward) predicting complications for coronavirus infected patients older than 20 years old.

|                | B          | S.E.    | Wald  | df | P     | Odds ratio (OR) | 95% CI. For OR Lower | 95% CI. For OR Upper |
|----------------|------------|---------|-------|----|-------|-----------------|-----------------------|----------------------|
| **Body mass index** | -0.301    | 0.086   | 12.090 | 1  | 0.001 | 0.740           | 0.625                 | 0.877                |
| **Diabetes**    | 4.090      | 1.444   | 8.026  | 1  | 0.005 | 59.728          | 3.527                 | 1011.464             |
| **Fever**       | 3.213      | 1.475   | 4.745  | 1  | 0.029 | 24.845          | 1.380                 | 447.291              |
| **Shortness of breath** | 2.765    | 1.266   | 4.770  | 1  | 0.029 | 15.873          | 1.328                 | 189.715              |
| **Neutrophils** | 2.822      | 1.456   | 3.755  | 1  | 0.053 | 16.814          | 0.968                 | 291.993              |

* Variable(s) entered on step 1: body mass index, diabetes, fever, myalgia, shortness of breath, age, lymphocytes, neutrophils.  
* Variable as continuous scale.
* Variable as dichotomous category.

It was noticed that 42.4% of infected patients were younger than 20 years, this may be because Jordan has a young population where the median population age is 22 years [19]. Family relationship and social lifestyle in Jordan encourages closeness, which makes social distancing more difficult. Data show that almost all the infected patients younger than 20 years had at least one infected individual of their families in the older age categories. However, no patient at this age group has developed any complications. Accordingly, they were not included in our univariate or multivariate analysis.

The age distribution of infected patients differed between countries. In Jordan for example, in the present study, we had only one infected patient older than 75 years, who was in the progression group, while data from USA [13] suggested that strongest hospitalization risk was age ≥75 years (OR = 66.8, 95% CI, 44.7–102.6). Data from Italy [7] showed that among 1591 patients admitted to ICU, 363 (22.8%) were older than 70 years, this percentage is significantly higher than data in Jordan. However, age ranges in Jordan may be close to those presented in china by Liu et al. [12] and to lesser extent data presented by Wu et al. [5], where median age was 38 (33, 57) and 51 (43–60) respectively.

The strongest predictors for a complicated course in our data were diabetes and fever. Both predictors had been identified by Wu et al. [5] in their cox regression as factors associated with the acute respiratory distress syndrome development, where Hazard Ratio (HR) for Diabetes was 2.34 (95%CI: 1.35–4.05, \( p = 0.002 \)) and HR for fever was 1.77 (1.11–2.84, \( p = 0.02 \)). In the same manner, fever had been also identified as a strong predictor for disease progression by Liu et al. [12] with the odds of 8.999 (95% CI: 1.036–78.147, \( p = 0.046 \)) but diabetes failed to be demonstrated as a risk factor in their data.

Current results confirmed that early SOB is a strong indicator for complications, where having SOB increases the odds for com-

### Discussion

Jordan has successfully managed to control the first wave of spread of the SARS-CoV2 virus, by implementing early lockdowns. The lockdown began on March 18th, 2020, at a time when the total number of known cases of the virus was less than 20. Jordan closed its borders on March 16th and kept the arriving passengers in quarantine. Extensive contact tracing was carried out, to control the spread of the virus [17,18]. These measures resulted in Jordan having less COVID 19 cases per capita compared to other countries; by May 2nd, 2020 Jordan had 54 cases/1 million population (1 M pop) and 0.9 deaths/1 M pop, compared to Portugal with about the same population and 2470 cases/1 M pop and 100/1 M pop death, Greece, with 251 cases per 1 M pop and 14 deaths/1 M pop. Lebanon 104 cases/1 M pop and 4 deaths/1 M pop. Having patients positive for the virus admitted to the hospital provided an opportunity to study risk factors for developing complications.
complications by 15.9 (95% CI: 1.3–189.7, p = 0.029). This supports others’ work as Wu et al. [5], who reported that patients developed acute respiratory distress syndrome have more percentage of patients with dyspnea compared to those who recovered 59.5% vs 25.6% respectively. While age is a well-defined risk factor for complications [5,12,13], its impact in our analysis was attenuated by multivariable adjustment for other variables, this might be due to the comparable age scale between the two study groups in the present study.

The D-dimer was documented as a strong factor associated with progression and subsequent death in China [5,11] and the USA [13] but not Italy [7]. In Jordan, the sample size for patients who underwent the D-dimer test was very small as seen in Table 5. Accordingly, with reference to these reasons and with the results documented by Liu et al. [12], we decided to skip D-dimer from the prediction model. Similarly, missing data for procalcitonin levels had prevented the addition of it to the prediction model in the present study.

In the current prediction model cardiac related problems, abnormal levels for C-reactive protein, and creatinine failed to demonstrate a statistically significant association with complications, unlike results shown by other researchers [12,13]. Our data did not identify smoking as risk factor for complication, this result is not supporting Liu et al. [12] research in china, but it is in line with result founded in USA by Petrelli et al. [13]. Nevertheless, smoking assessment may be widely differed between health care providers, in addition to factors as quantity and duration of smoking habit. Finally, Treatment with hydroxychloroquine failed to demonstrate a protective effect within Jordanian patients, as identified by univariable analysis.

Conclusion

With reference to the prediction model for Jordan and the Middle East, patients identified with fever, shortness of breath, and diabetes should be closely supervised and observed. They have an increased risk for complications. Smoking was not identified as a risk factor for complications, and hydroxychloroquine treatment had no benefit.

Authors contributions

MO contributed to study design, data analysis, and writing. RA, AT, MK, RT, and AA contributed to study design, data collection, and manuscript writing. KA participated in study design, manuscript writing.

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Competing interests

None declared.

Ethical approval

Not required.

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