Relative Risk of Coronavirus Disease-19 (COVID-19) Infection and Disease Outcomes with ABO Blood Type among Hospitalized Filipino Patients from Select Tertiary Hospitals in Metro Manila, Philippines: An Ambispective Cohort Analysis

John Rey B. Macindo[1], Christian Albert F. Soriano[1], Paula Bianca E. Nuqui[2], Gian Carlo S. Torres[1], and Maria Rhona G. Bergantin[2]

[1]TOP UP Training Center and Research Consultancy Inc
[2]University of Santo Tomas Hospital

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Abstract

Background: The increasing COVID-19 cases and rising scientific interest on the role of ABO blood type in disease susceptibility and outcomes highlight the need to explore the associations among Filipinos, cognizant of racial and genetic predisposition. This study determined the relative risk of COVID-19 infection and disease outcomes with ABO blood type among Filipino patients. **Methods**: Employing an ambispective cohort, 550 consecutively-selected, hospitalized Filipino adult patients with SARS-CoV-2 RT-PCR result were included. Medical records of previously admitted patients were retrospectively reviewed and pertinent data were extracted. Prospectively, patients who were still admitted were recruited and followed-up. Risk ratio estimated the risk of primary (COVID-19 infection and severity) and secondary outcomes (ICU admission, intubation, and mortality). **Findings**: The risk of COVID-19 infection was 20% higher among type A (aRR=1·20, p=0·021) but was 19% lower among type O (aRR=0·84, p=0·023). Blood type A (aRR=1·25, p=0·041) was 25% at greater risk for severe-to-critical COVID-19 infection, while moderate COVID-19 was 62% higher among type AB (aRR=1·62, p=0.037) and was 54% lower among type O (aOR=0·65, p=0·010). ABO blood type did not predict any disease outcomes. **Interpretation**: ABO blood type was an independent predictor of COVID-19 infection and severity but not disease outcomes. Type A has higher risk for COVID-19 infection and severe-to-critical COVID-19, while type O had lower risk. This information can be utilized in identifying the population-at-risk, developing programs and interventions, increasing vigilance in medical management, and promoting adherence to precautionary and protective health-seeking behaviors. **Funding**: Philippine Council for Health Research and Development

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Keywords*: ABO Blood Type; COVID-19; COVID-19 Disease Outcomes; COVID-19 Infection; COVID-19 Severity; Filipino*

INTRODUCTION

Coronavirus disease 2019 (COVID-19) is an infectious disease caused by a new strain of coronavirus which was initially unknown until its outbreak in Wuhan, China last December 2019, and it has been declared as a Public Health Emergency of International Concern by the World Health Organization.[1] In the Philippines, the total number of positive COVID-19 cases has risen to more than 65,000 Filipino by mid July 2020, and it continuously rose to more than 4·10 million cases by June 2023.[2]

As the COVID-19 pandemic spreads worldwide and the number of affected individuals rises, the healthcare system of the Philippines has been greatly challenged,[3] making the identification of individuals at greatest risk a key challenge.[4]Cognizant of the significant mortality and morbidity associated with COVID-19, scientific interest in identifying the characteristics which increases susceptibility to the disease and factors which determine its progression, severity, and prognosis has increased.[5-7]

One of the characteristics that has recently gained scientific interest is the association of the ABO blood type with COVID-19 infection susceptibility. It is hypothesized that the ABO carbohydrate moieties are genetically inherited, and it is associated with certain conditions and diseases such as cardiovascular diseases, cancer, and certain infections, including coronavirus infections.[4,7,8]With the increasing number of COVID-19 cases and the increasing scientific interest in the association of ABO blood type and COVID-19 susceptibility and outcomes, it is imperative to determine this association among Filipino patients. This knowledge can help medical professionals further determine the relative risk of specific Filipino subpopulations for COVID-19 and its outcomes. This study determined the relative risk of COVID-19 infection and disease outcomes (ICU admission, intubation, and mortality) with ABO blood type among the hospitalized Filipino patients from select tertiary hospitals in Metro Manila, Philippines.

METHODS

Research Design

This study utilized an ambispective, cohort design. The retrospective aspect included collection of exposure and outcomes according to sequence of events from medical records, while the prospective aspect involved following-up patients for their outcomes according to exposure status. The Strengthening the Reporting of Observational studies in Epidemiology (STROBE) checklist (see Supplementary File) was observed in reporting this paper.

Sample and Setting

This study was conducted in six tertiary medical institutions within Metro Manila, Philippines which cater the medical needs of COVID-19 patients. Patients were eligible if they were at least 18 years old; Filipino citizen; hospitalized in the selected hospitals in Metro Manila, regardless of clinical symptomatology and case severity, from March 2020 to January 2022; have real time polymerase chain reaction (RT-PCR) result test via nasopharyngeal and/or oropharyngeal swabs in an accredited laboratory; and, have blood typing result. Medical records with incomplete data were excluded.

Sample size computation (*priori*) for binary logistic regression analysis was conducted using GPower version 3.1.9.4. According to Latz et al.,[6] the odds ratio for COVID-19 infection was 1·37 for blood type AB, with a null probability of 19·80% and R^2-value of 0·005. With these parameters, a minimum power of 80%, and a significance level of 5% (two-tailed), a minimum sample size of 401 respondents was necessary. The sample size was inflated to accommodate 20% attrition; hence, the final sample size was at least 502 respondents.

Study Outcomes and Data Measures

The exposure variable was the ABO blood type, which was based on blood typing result available in the medical records, and the comparison/control group was the absence of specific blood type antigen (e.g., Type A vs. Non-A Blood Type; Type B vs. Non-B Blood Type; Type AB vs. Non-AB Blood Type; Type O vs. Non-O Blood Type). The primary outcome was COVID-19 infection and severity which were based on the RT-PCR result and the national and international interim guidelines on COVID-19, respectively. The secondary outcomes were ICU admission, intubation, and mortality.

The data were recorded in an abstraction form which included demographic data, medical and clinical data, and the COVID-19 infection data. Demographic data included birthdate, sex, marital status, educational attainment, and occupation. The medical and clinical data involved the chief complaint; admission and final diagnoses, admission date, unit of admission, comorbidities, medications, anthropometric measurements, blood chemistry and inflammatory markers, medical managements, blood type, ICU admission and discharge, intubation and/or extubation, duration of hospital and ICU stays, and mortality. Finally, COVID-19 infection data included the date of RT-PCR specimen collection and result, the test result, clinical category, clinical symptomatology, and results of chest radiographic imaging, if any.

Data Collection Procedure and Ethical Considerations

Institutional approval and ethical clearance were initially secured from the institution and their respective Research Ethics Committees. Data collection was conducted from August 2021 to January 2022. For the retrospective aspect, a list of previously admitted patients at the start of the study, had blood typing, and had RT-PCR was initially requested. Afterwards, the medical records of these patients were screened and reviewed before extracting and recording pertinent information in the abstraction form. For patients who were still admitted at the start of the study, a list was secured from the different hospital unit. Eligible patients, or their legally authorized representative, were invited to participate and were provided full disclosure before securing written informed consent. The medical records of these patients were then reviewed and pertinent demographic, medical and clinical, and COVID-19 infection data were collected and recorded in the abstraction form. These patients were then followed-up during their hospitalization for COVID-19 disease outcomes.

Data Analysis

Statistical analyses were conducted using STATA MP-Parallel Edition Statistical Software, Version 18, College Station, TX: StataCorp LP. A p -value of 0·05 was considered statistically significant. Descriptive statistics included mean and standard deviation for continuous-level data, median and interquartile range for ordinal data, and frequency and proportion for nominal data. Comparative analyses of demographic and clinical characteristics and study outcomes according to ABO blood type included Chi-Square Test of Homogeneity or Fisher's Exact Test, Kruskall-Wallis H Test, and one-way Analysis of Variance (ANOVA). Relative risk of COVID-19 infection, disease severity, and disease outcomes (ICU admission, intubation, and mortality) according to ABO blood type was measured using risk ratio (RR), which was estimated using log-binomial

regression.[9] Crude risk ratios (cRR) were initially estimated. Afterwards, significant confounders were screened, analyzed, and controlled using a 10% change-in-estimate criterion[10] to estimate the adjusted risk ratio (aRR).

RESULTS

From 761 records and 152 patients followed-up for a mean follow-up of 7·93 days (SD=7·49, Range=1 to 47), a total of 550 patients were eligible and included.

Demographic and Clinical Profiles

Table 1 illustrates the demographic and clinical profiles of the patients. From the multicenter data, the most common blood type was type O (36·90%) followed by type A (31·30%) and type B (26·00%), while type AB was only seen in 5·80%. The mean age was 48·97 years old (SD=14·74), and majority were female (61·45%), married (87·82%), had tertiary education (78·82%), and employed (67·23%) as non-healthcare workers (80·90%).

The most prevalent comorbidity was hypertension (40·91%), and almost a quarter were on anti-hypertensive medications. The mean peak creatinine, peak white blood cell count, and mean peak inflammatory markers were above the normal values. The mean oxygen saturation upon admission was 95·19% (SD=6·73), with most patients not requiring oxygen supplementation (69·09%). Among those with oxygen support, majority had low dose oxygen (21·64%) at a mean of 30·36% FiO_2(SD=22·16). Over the course of hospitalization, oxygen support from admission did not change for most patients (68·91%).

[INSERT TABLE 1 HERE]

COVID-19 Clinical Profile and Disease Outcomes

More than half of patients (59·45%) were confirmed COVID-19 cases, with majority having moderate COVID-19 (24·55%) (Table 2). The most common clinical symptomatology were cough (27·64%), dyspnea (23·64%), and fever (23·45%), and 28·72% had lung infiltrates. In terms of vaccination, majority were unvaccinated (75·64%), with only 22·18% completing their COVID-19 vaccination. Results also showed that only 10·91% were admitted in the in intensive care unit, 9.09% were intubated, and 6·55% had expired. The mean duration of ICU stay was 12·65 days (SD=12·48), while the mean duration of hospital stay was 10·33 days (SD=11·23).

[INSERT TABLE 2 HERE]

Risk of COVID-19 Infection with Blood Type

Analyses indicated that ABO blood type independently predicted COVID-19 infection (Table 3). At crude analyses, blood type A and O significantly predicted the risk of COVID-19 infection. After controlling for significant confounders (age and COVID-19 vaccination), the adjusted risk for COVID-19 infection was 20% higher among blood type A (aRR=1·20, p =0·021) than non-A blood type. In contrast, those with blood type O (aRR=0·85, p =0·023) were 19% at lower risk than non-O blood type.

[INSERT TABLE 3 HERE]

Risk of COVID-19 Disease Severity with Blood Type

Crude and adjusted analyses showed that ABO blood type significantly predicted the risk of COVID-19 severity (Table 4). Adjusted analyses, upon controlling age and COVID-19 vaccination, revealed that blood type A was 52% and 25% at greater risk for developing asymptomatic-to-mild (aRR=1·52, p =0·040) and severe-to-critical COVID-19 (aRR=1·25,p =0·041), respectively. Blood type AB, on the other hand, was 62% at higher risk for moderate COVID-19 (aRR=1·62, p =0·037) compared to non-AB blood type. Interestingly, those with blood type O (aRR=0·65, p =0·010) have a lower risk for moderate COVID-19 by 54%.

[INSERT TABLE 4 HERE]

Risk of Disease Outcomes with Blood Type

As presented in Table 7, crude analyses for the risk of ICU admission, intubation, and mortality did not reveal statistically significant associations. Even after adjusting for confounders (age, comorbidity of diabetes mellitus and chronic kidney disease, COVID-19 severity, and COVID-19 vaccination status), ABO blood type did not predict the risk of these disease outcomes.

[INSERT TABLE 5 HERE]

DISCUSSION

This study determined the relative risk of COVID-19 infection and disease outcomes with ABO blood type of hospitalized Filipino patients from Metro Manila, Philippines. To the best of the researchers' knowledge, this is the first study conducted in Metro Manila, Philippines which explored the associations of ABO blood type with COVID-19 infection and disease outcomes of hospitalized patients. By and large, results indicated that ABO blood type independently predicted the risk COVID-19 infection and severity. Blood type A was 20% at greater risk for COVID-19 infection and had higher risk of developing asymptomatic-to-mild and severe-to-critical COVID-19 by 52% and 25%, respectively. Blood type AB, for this part, increased the risk of moderate COVID-19 by 62%. Blood type O, however, decreased the risk of COVID-19 infection by 19% as well as the risk of moderate COVID-19 by 54%. It was also noted that ABO blood type did not predict the risk of ICU admission, intubation, and mortality.

It is interesting to note that the distribution of blood types was consistent with previous studies, showing that most Filipinos were blood type O, followed by type A, type B, and type AB.[11]Analyses also showed that the most common clinical manifestations of confirmed COVID-19 patients were cough, dyspnea, and fever. These signs and symptoms are closely similar to the early manifestations noted in Wuhan, with fever as the most common symptomatology.[12]It should also be noted that although most patients had normal chest radiographic imaging, those with abnormal chest X-ray commonly presented with bilateral infiltrates, comparable with findings in Italy.[13,14] In contrast, the commonly reported ground-glass opacity in chest CT scan and pleural line changes in chest sonography[13] were not commonly seen among the included patients.

From the 43 different blood group systems recognized by the International Society of Blood Transfusion,[15] the ABO blood classification is the most researched and associated with disease occurrence, including cardiovascular conditions, venous thromboembolism,[16] rheumatologic diseases,[17] malignancies and oncologic conditions, and infectious diseases.[8] Among infectious diseases, tuberculosis,[18] hepatitis, human immunodeficiency virus,[19] and dengue[20] have been associated with the ABO system.

Over the past years, research on the association of COVID-19 and ABO blood type have been conducted.[4,6,21–26] In the study of Kim et al.,[23] eight of the nine reviewed articles showed an association between ABO blood type and COVID-19 infection. Additionally, Muñiz-Diaz et al.[23] noted that the risk of COVID-19 was 23% higher for blood type A but was 27% lower for blood type O. Earlier studies also showed a similar trend, wherein the risk of COVID-19 was higher with blood type A but was lower with blood type O,[4,22,24–26] and this was also observed in the genome-wide association study in Spain and Italy.[27]Consistent with our results, the risk of COVID-19 infection was 20% higher with blood type A, while there is a 19% lower risk with blood type O, and these associations were hypothesized to be due to the ABO antigens on red blood cells. These antigens are carbohydrates encoded by the antigen-coding gene in chromosome 9[25] and are synthesized through fucosylation of the core glycan and binding of fucose moiety at the non-terminal sugar residue end of the core glycan. This fucosylated core glycan, or H antigen, undergoes enzymatic activity through chromosome 9 and modifies the H antigen according to allelic variant. For blood type O, the allele gene product is devoid of enzymatic activity thus, cannot attach any terminal sugar at the H antigen. In contrast, blood type A receives a terminal N-acetylgalactosamine moiety, blood type B transfers a terminal galactose moiety, and blood type AB develops both moieties of blood type A and B.[28] In COVID-19, its infection mechanism has been associated with the terminal galactosamine and galactose moieties in A and B antigens, respectively.[29] The spike protein of SARS-CoV-2 virus binds with carbohydrates and has a strong affinity to galactosamine and galactose terminals thus, may facilitate viral binding and cellular uptake.[4,7,29] It was also noted that Thr323 and Ser325 are glycosylation sites at the

receptor-binding domain of the S1 subunit of SARS-CoV-2 virus hence, potentiating viral binding to host cell and infection.[29]

Notably, ABO blood type was associated with COVID-19 severity. Among the 327 confirmed COVID-19 patients, majority had moderate infection (41·28%) followed by severe-to-critical infection (35·17%). Factoring the effects of blood type, patients with blood type A were 52% and 25% at higher risk asymptomatic-to-mild and severe-to-critical COVID-19, respectively. Those with blood type AB were 62% at higher risk of moderate COVID-19, while blood type O reduced the risk of moderate infection by 54%. These associations, however, were not evident in previous studies.[6,21,25] Nevertheless, despite insufficient evidence on the exact mechanisms for such associations, some studies proposed that it was attributed to increased activity and levels of angiotensin-converting enzyme 2 (ACE-2); Von Willebrand factor and Factor VIII; and, angiotensin-converting enzyme (ACE-1).[30] The GATC haplotype of polymorphisms in the ABO gene increases ACE2 receptor activity, which is prevalent among non-O blood type.[27] Thus, this upregulation promotes viral adherence and invasion of host cells of non-O blood types. In addition, patients with blood type O have lower ACE levels and have more protection against SARS-CoV-2 virus.[30] It has also been proposed that the high levels of ACE1, Von Willebrand factor, and Factor VIII among patients with the A antigen predispose this population to severe forms of COVID-19, cardiovascular complications, and thromboembolic events.[30]

In our study, ABO blood type was not predictive of ICU admission, intubation, and mortality, even after controlling for significant confounders, which was parallel with the findings of various authors.[21,25] However, some evidence showed significant associations between ABO blood type and COVID-19 disease outcomes. Ray et al.,[27] for one, noted that blood type O had a protective effect against severe illness or death, decreasing the odds by approximately 15%. Hoiland et al.[22] also estimated that the hazards of mechanical ventilation and mortality were 76% and 22% higher for blood types A and AB, respectively, compared to blood type O. In the study of Muñiz-Diaz et al.,[24]blood type O decreased the odds of mortality by 33%, while type A had 39% higher odds of mortality. However, the results of these studies did not account for certain factors which may affect the reported associations, such as ethnic origin, small sample sizes, and ancestry.[22,24,26]

This study has certain limitations. First, the COVID-19 variant was not included cognizant that certain variants have the propensity for severe forms of COVID-19. Second, some records of suspected COVID-19 cases were not included due to the lack of an RT-PCR result before their untimely death, especially at the start of the COVID-19 pandemic in the Philippines. Third, only Rhesus positive (Rh+) patients were included since the Filipino population is predominantly Rh+, with less than 1% being Rh–.[11] Fourth, our study was conducted in select tertiary hospitals in Metro Manila and does necessary reflect the risk of the general healthy population. Finally, our study only included the admission COVID-19 severity and did not include the progression to higher levels of severity.

CONCLUSION

The ABO blood type was an independent predictor of COVID-19 infection and severity but not the disease outcomes. Blood type A increased the risk of developing COVID-19 infection as well as the risk of asymptomatic-to-mild and severe-to-critical forms of COVID-19. In contrast, the risk of COVID-19 infection and moderate COVID-19 was lower among blood type O.

The results of this study offer theoretical and clinical implications. Theoretically, this study contributes to the growing knowledge on COVID-19 and disease outcomes among Filipinos. Noting that race and ethnicity can affect disease predisposition, disease outcomes, and blood type, understanding these risks is imperative for clinical practice and policy development. On an applied level, understanding the risk of COVID-19 infection and severity across ABO blood type can assist medical professionals in identifying the population-at-risk and develop programs and interventions for risk minimization. Understanding that blood type A increases the risk for COVID-19 infection and its severe forms can implore healthcare professionals to become more vigilant in their medical management of this population. Although this knowledge does not replace the precautionary measures and therapeutic approaches against COVID-19 infection, this information can educate the general Filipino population of their potential risk thus, may promote adherence to precautionary measures and

protective health-seeking behaviors against COVID-19.

Contributors

JRBM, CAFS, PBEN, GCST, and MRGB were responsible the conceptualization of the study and formulation of study methodologies. JRBM and CAFS participated in the collection of data, while JRBM and GCST conducted the statistical analyses. JRBM, CAFS, PBEN, GCST, and MRGB contributed in interpreting the results and drafting and critically revising the final paper. JRBM, CAFS, PBEN, GCST, and MRGB all approved the final paper.

Declaration of Interest

This study received financial support and assistance from the Philippine Council for Health Research and Development (PCHRD). The authors have no other conflict of interest to declare.

Role of the Funding Source

This study received financial support and assistance from the PCHRD. The funding agency had no role in the conceptualization of study design and methodologies, data collection, statistical analysis, data interpretation, and writing of the report for publication.

Data Sharing

Data may be made available according to the data-sharing policies of the funding agency. Requests for data should be addressed to the corresponding author.

REFERENCES

1 Department of Health (DOH). COVID-19 Case Tracker [Internet]. Manila, Philippines: DOH; 2022. Available from: https://www.doh.gov.ph/covid-19/case-tracker

2 World Health Organization. Coronavirus disease (COVID-19) in the Philippines [Internet]. Philippines: WHO; 2020. Available from: https://www.who.int/philippines/emergencies/covid-19-in-the-philippines

3 Phua J, Weng L, Egi M, Lim CM, Divatia JV, Shrestha BR, et al. Intensive care management of coronavirus disease 2019 (COVID-19): Challenges and recommendations. *Lancet Respir Med* 2010;**8** (5): 506–17. https://doi.org/10.1016/S2213-2600(20)30161-2

4 Zietz M, Zucker J, Tatonetti NP. Testing the association between blood type and COVID-19 infection, intubation, and death. *Nat Commun*2020; **11** : 5761. https://doi.org/10.1038/s41467-020-19623-x

5 Hussain A, Bhowmik B, do Vale Moreira NC. COVID-19 and diabetes: Knowledge in progress. *Diabetes Res Clin Pract* 2020;**162** : 108142. https://doi.org/10.1016/j.diabres.2020.108142.

6 Latz CA, DeCarlo C, Boitano L, Png CY, Patell R, Conrad MF, et al. Blood type and outcomes in patients with COVID-19. *Ann Hematol*2020; **99** (9), 2113–18. https://doi.org/10.1007/s00277-020-04169-1

7 Zhao Q, Meng M, Kumar R, Wu Y, Huang J, Lian N, et al. The impact of COPD and smoking history on the severity of COVID-19: A systemic review and meta-analysis. *J Med Virol* 2020; **92** (1): 1915–21. https://doi.org/10.1002/jmv.25889

8 Liumbruno GM, Franchini M. Beyond immunohaematology: The role of the ABO blood group in human diseases. *Blood Transfus* 2013;**11** (4): 491–9. https://doi.org/10.2450/2013.0152-13

9 Daniel WW, Cross CL. Biostatistics: A foundation for analysis in the health sciences. 10$^{\text{th}}$ ed. USA: John Wiley & Sons, Inc; 2013.

10 Budtz–Jørgensen E, Keiding N, Grandjean P, Weihe P. Confounder selection in environmental epidemiology: Assessment of health effects of prenatal mercury exposure. *Ann Epidemiol* 2007;**17** (1): 27–35. https://doi.org/10.1016/j.annepidem.2006.05.007

11 Guzman RMS, Gervasio RNR, Fontanilla IKC, Cao EP. Frequency distribution of blood groups ABO, MN and Rh factor in Philippine cosmopolitan, regional, and the national populations. *Sci Diliman*2010; **21** (2): 43–9.

12 Wang C, Horby PW, Hayden FG, Gao GF. A novel coronavirus outbreak of global health concern. *Lancet* 2020; **395** (10223): 470–3. https://doi.org/10.1016/S0140-6736(20)30185-9

13 Kaufman AE, Naidu S, Ramachndran S, Kaufman DS, Fayad ZA, Mani V. Review of radiographic findings in COVID-19. *World J Radiol* 2020;**12** (8): 142–55. https://doi.org/10.4329/wjr.v12.i8.142

14 Vancheri SD, Savietto G, Ballati F, Maggi A, Canino C, Bortolotto C, et al. Radiographic findings in 240 patients with COVID-19 pneumonia: Time-dependence after the onset of symptoms. *Eur Radiol* 2020;**30** (11): 6161–9. https://doi.org/10.1007/s00330-020-06967-7

15 International Society of Blood Transfusion. Red Cell Immunogenetics and Blood Group Terminology. International Society of Blood Transfusion [Internet]. Amsterdam, the Netherlands: International Society of Blood Transfusion; 2022. Available from: https://www.isbtweb.org/isbt-working-parties/rcibgt.html

16 Dentali F, Sironi AP, Ageno W, Turato S, Bonfanti C, Frattini F, et al. Non-O blood type is the commonest genetic risk factor for VTE: Results from a meta-analysis of the literature. *Semin Thromb Hemost* 2012; **38** (5): 535–48. https://doi.org/10.1055/s-0032-1315758

17 Çildağ S, Kara Y, Şentürk T. ABO blood groups and rheumatic diseases.*Eur J Rheumatol* 2017; **4** (4): 250–3. https://doi.org/10.5152/eurjrheum.2017.17044.

18 Garratty G. Blood groups and disease: A historical perspective.*Transfus Med Rev* 2000; **14** (4): 291–301. https://doi.org/10.1053/tmrv.2000.16228

19 Batool Z, Durrani SH, Tariq S. Association of ABO and Rh blood group types to hepatitis B, hepatitis C, HIV and syphilis infection: A five year' experience in healthy blood donors in a tertiary care hospital.*J Ayub Med Coll Abbottabad* 2017; **29** (1): 90–2.

20 Murugananthan K, Subramaniyam S, Kumanan T, Owens L, Ketheesan N, Noordeen F. Blood group AB is associated with severe forms of dengue virus infection. *Virusdisease* 2018; **29** (1): 103–5. https://doi.org/10.1007/s13337-018-0426-8

21 Barnkob MB, Pottegård A, Støvring H, Haunstrup TM, Homburg K, Larsen R, et al. Reduced prevalence of SARS-COV2 infection in ABO blood group O. *Blood Adv* 2018; **4** (20): 4990–3. https://doi.org/10.1182/bloodadvances.2020002657

22 Hoiland RL, Fergusson NA, Mitra AR, Griesdale DEG, Devine DV, Stukas S, et al. The association of ABO blood group with indices of disease severity and multiorgan dysfunction in COVID-19. *Blood Adv* 2020;**4** (20): 4981–9. https://doi.org/10.1182/bloodadvances.2020002623

23 Kim Y, Latz CA, DeCarlo CS, Lee S, Maximilian Png CY, Kibrik P, et al. Relationship between blood type and outcomes following COVID-19 infection. *Semin Vasc Surg* 2021; **34** (3): 125–31. https://doi.org/10.1053/j.semvascsurg.2021.05.005

24 Muñiz-Diaz e, Llopis J, Parra R, Roig I, Ferrer G, Grifols J, et al. Relationship between the ABO Blood group and COVID-19 susceptibility, severity and mortality in two cohorts of patients. *Blood Transfus*2021; **19** (1): 54–63. https://doi.org/10.2450/2020.0256-20

25 Rana R, Ranjan V, Kumar N. Association of ABO and Rh blood group in susceptibility, severity, and mortality of Coronavirus Disease 2019: A hospital-based study from Delhi, India. *Front Cell Infect* 2021;**11** : 767771. https://doi.org/10.3389/fcimb.2021.767771

26 Ray JG, Schull MJ, Vermeulen MJ, Park AL. Association between ABO and Rh blood groups and SARS-CoV-2 infection or severe COVID-19 illness: A population-based cohort study. *Ann Intern Med* 2021;**174** (3): 308–15. https://doi.org/10.7326/M20-4511

27 Ellinghaus D, Degenhardt F, Bujanda L, Buti M, Albillos A, Invernizzi P, et al. Genomewide association study of severe Covid-19 with respiratory failure. *N Eng J Med* 2020; **383** (16): 1522–34. https://doi.org/10.1056/nejmoa2020283

28 Kudelka MR, Ju T, Heimburg-Molinaro J, Cummings RD. Chapter three - simple sugars to complex disease—mucin-type O-glycans in cancer. In: Drake RR, Ball LE, editors. Glycosylation and Cancer. UK: Elsevier Inc.; 2015.

29 Chiodo F, Bruijns SCM, Rodriguez E, Li RJE, Molinaro A, Silipo A, et al. Novel ACE2-independent carbohydrate-binding of SARS-CoV-2 spike protein to host lectins and lung microbiota. *bioRvix* . https://doi.org/10.1101/2020.05.13.092478

30 Shibeeb S, Khan A. (2022). ABO blood group association and COVID-19. COVID-19 susceptibility and severity: A review. *Hematol Transfus Cell Ther* 2022; **44** (1): 70–5. https://doi.org/10.1016/j.htct.2021.07.006

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