# Is Blood Type Linked to COVID 19 Risk?

## Kan Grubu Türü COVID 19 Riski İle Bağlantılı mı?

**Hevi Ghafour, Mustafa Altındiş**

*Sakarya Üniversitesi Sağlık Bilimleri Enstitüsü Tibbi Mikrobiyoloji Anabilim Dalı, Sakarya*

Yazışma Adresi / *Correspondence:*
**Mustafa Altindiş**

Tıp Fakultesi Tibbi Mikrobiyoloji Anabilim Dalı, Korucuk, Sakarya
T: **+90 533 661 52 63** E-mail: **maltindis@gmail.com**

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Orcid:
**Hevi Seerwan Ghafour Ghafor https://orcid.org/0000-0002-5634-5257**
**Mustafa Altındiş https://orcid.org/0000-0003-0411-9669**

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**Abstract**

New coronavirus SARS-CoV-2 had been stressed healthcare since their quick worldwide propagation which is a crucial quarrel. It has been estimated that blood group could impact the risk of serios COVID 19. we performed a review by going through number of article published regarding this subject, and found out that blood group has different impact on COVID 19 infection accordingly, findinig slightly increased infection prevalence among non-O types, risk of intubation was decreased among A and increased among AB and B types, compared with type O. Also estimate Rh-negative blood type to have a protective effect to the high COVID 19 infection epidemiology, while risk of death was increased for type AB and decreased for types A and B. Studies add to the growing body of evidence suggesting blood type may play a role in COVID 19 infection but further studies are needed to investigate more.

*Keywords* COVID 19 virus disease; ABO blood group system; Epidemiology

**Öz**

*Yeni koronavirüs SARS-CoV-2'nin hızlı küresel yayılımı, sağlık hizmetlerini ve test kaynaklarını zorlayarak, en risk altındaki kişilerin tanımlanmasını kritik bir zorluk haline getirdi. Bu derleme çalışmasındaki yayınlara göre, kan grubu türünün COVID 19 enfeksiyon şiddeti riskini etkileyebileceğini göstermektedir. Kan grubu O'dan farklı olan kişiler arasında COVID 19 enfeksiyonu prevelansı biraz daha yüksek bildirilmektedir. Entübasyon riski, O kan grubu baz alındığında, A kan grubunda azalmış; AB ve B kan gruplarında artmış olarak saptanmıştır. Rh-negatif kan grubunun COVİD 19 enfeksiyon riskine karşı koruyucu etkisi olduğu; mortalite riskinin AB kan grubunda artmış A ve B kan gruplarında azalmış olduğu tahmin edilmektedir. Kan grubunun COVID 19'da rol oynayabileceğini öne süren kanıtlar artmakla birlikte bu konuda daha çok araştırmaya ihtiyaç vardır.*

*Anahtar Kelimeler* *COVID 19; ABO kan grubu sistemi; Epidemiyoloji*

## INTRIODUCTION

### 1. SARS CoV-2, COVID 19 and Pandemic

COVID 19 disease, caused by the SARS-COV-2 virus had rised at Wuhan province in China in Dec, 2019. and this disease affected the entire world in a short time.[1] The Virus Taxonomy International Committee formally decleared term to the novel coronavirus as "Severe Acute Respiratory Syndrome Coronavirus 2" (SARS-CoV-2). Then, world Health Organization (WHO) has stated formal noun of the infection occured by SARS-CoV-2 as Corona Virus Disease 19 (COVID 19). On March 11, 2020 WHO changed the status of COVID 19 epidemic to be pandemic.[2,3] COVID 19 propagate quickly through world which had been resulted in more than 68.252.608 million certain cases also above 1.557.343 death universaly up to December 9, 2020.[3]

COVID 19 infection incubation period ranges from 2 to 14 days.[4] While incubation duration Individuals are contagious, might asymptomatic infection also act as the origin of the disease. Incubating patients, asymptomatic patients continue to spread the COVID 19 virus.[5,6] Such individuals can contribute to the spread of infection in society, the most widespred clinical features of COVID 19 disease are respiratory symptoms characterized by fever, fatigue and dry cough These clinical features show a broad spectrum of diseases ranging from mild to severe symptoms of influenza-like respiratory syndrome which complexes by pneumonia and acute respiratory distress syndrome (ARDS), high fever, headache.[7] In very severe cases, infected persons can be subjected to septic shock, acute respiratory distress syndrome, and might result mortality.[5,6] In data from China, about 80% of patients infected by COVID 19 had moderate to mild illness including pneumonia, nearly 14% had intense disease with blood oxygen saturation level (93%), and 6% reported crucial illness with septic shock, respiratory failure, and/or severe multi-organ inability or dysfunction.[8]

A global pandemic causing by COVID 19 disease has resulted in a quick rise in case and death rates. Mortality rate of this viral infection was almost about 2-3 percent and intensive respiratory diseases was associated with.[1] community had been impacted by raising COVID 19 disease. Elder individuals with cormorbid disease, such as cancer, cardiovascular disease, diabetes and immunosuppressive disease, have a higher risk of infection and complications and are more likely to get to the infection.[9]

Considering that COVID 19 disease has caused significant morbidity and mortality, there has been scientific concern in choosing information that specifying distinctives which might cause people most likley to get COVID 19 disease, also deciding which risk agents might contribute to the leading and seriosity of illness caused by a virus.[10] It has been reported that there are variety of risk agents regarding COVID 19 morbidity and mortality, containing age, smoking, chronic cardiovascular disease, sex, diabetes, hypertension and respiratory illnesses.[11]

Since the 1950s a correlation of human ABO blood group types with numerous illnesses had been recognized.[12] It has been pointed out that there is a relationship amongst ABO blood group, cancers, cardiovascular illnesses, also sensitivity to particular diseases, inclusive coronavirus – SARS For instance, non-O blood types people were very susceptible to promote coronary heart illness with venous thromboembolism in contrast to O blood group individual.[13] Lately, various researches regarding COVID 19 in China and America figuered relationship among ABO blood type with COVID 19 disease, severity along with decease Potential correlation among blood group A with a higher risk for COVID 19 infection together with mortality Has been found out in a study while in the same study O blood group had contributed to less risk of disease and mortality Zietz and Tatonetti stated as blood type A was related to a higher priority of checking positive for COVID 19 infection.[14]

In this review, the goal was to define s a relationship among

ABO blood type, risk of COVID 19 infection and if there is changeability in checking positive for COVID 19 infection among blood groups.

### 1.1. Viral Classification

The SARS-CoV-2 virus belongs to coronaviridae family due to their similarity in nucleic acid sequences to acute respiratory coronavirus syndrome (SARS-CoV) and Middle East respiratory coronavirus syndrome (MERS-CoV) viruses. SARS-CoV, MERS-CoV which recognized as coronaviridae family of viruses. In 2002 and 2013, those viruses (SARS-CoV in china and MERS-CoV in Saudi Arabia) resulted in serious human infections like severe pneumonia and bronchiolitis, meningitis even among most vulnerable societies, the virus family categorised into four genera: alpha, beta, gamma, and delta. While alpha coronaviruses are representative of four low-pathogenicity human coronaviruses HCoV-OC43, HCoV-HKU1, HCoV-NL63, and HCoV-229E. beta-coronaviruses are include the most well-known and more pathogenic zoonotic pathogens SARS-CoV and MERS-CoV, Coronaviruses are positive-sense, single-stranded RNA genome, which are enclosed into an envelope, Upper respiratory and digestive tract infections are primarily goes under the responsiblity of CoVs. Based on its sequence of genomes, 2019-nCoV shares almost 76% of the amino acid sequence similarity with SARS-CoV in the Spike (S)-protein sequence and 80 percent along with CoV ZXC21.[1,15,16]

SARS-CoV and SARS-CoV-2 utilize the similar receptor which is ACE2, for entrance into target cells.[17] Which had attracted the attention of the scientist to explore if the ABO blood group polymorphism is additionally related to host sensibility to SARS-CoV-2 infection. The hypotheses linked for this contribution include the prevalence and division of particular genetic loci.[18]

### 1.2. Pathogenesis

Attaching virus particle to the host superficies cellular receptors initiating the Viral infections. Therefore receptor realization is a crucial recognization of the cell and tissue tropism of the viral particle. Additionaly, obtaining function of a virus in order to attach to receptor takes place in other species which also is a precondition as inter-species transition.[19]

The S-protein coronavirus is the constitutionall protein which is accountable to tiara-like shape of viral CoV particles from which the initial noun "coronavirus" was stated. S-protein belongs to class I viral fusion proteins and linked to cell receptor attaching, tissue tropism, and pathogenesis. so for entrance and infecting cells, coronavirus must recognize (via its surface spike glycoprotein), bind to a membrane receptor (protein, lipid carbohydrate).[1,15]

Suprisingly, by exclusion of HCoV-OC43 and HKU1, which they had exhibit to utilize sugars for cell binding, in the other hand else human CoVs sense proteinaceous peptidases as receptors. HCoV-229E attaches to human aminopeptidase N , and MERS-CoV interacts with human dipeptidyl peptidase 4. SARS-CoV and hCoV-NL63 react together with angiotensin-converting enzyme 2 (ACE2) as the entrance into human cells In virtually all organs such as numerous extrapulmonary locations through the aerodigestive tract, containing the mucosa of the oral cavity of the heart, blood vessels, kidneys, and testes were found to be expressed ACE2 mRNAs.[15,20,21,22]

In a study in China, the ABO blood type was contributed to ACE activity which ACE inhibitor-induced cough between Chinese patients with hypertension an angiotensin-converting enzyme 2 (ACE2), an aminopeptidase that works like a putative receptor. Several in-vitro studies have found a positive association among ACE2 membrane expression and / or tissue activity and the risk of COVID 19 infection.[15,23]

### 1.3. Transmission

Bat has been considered to play role as a reservoir for the majority of human coronaviruses. Two of SARS-CoV and

SARS-CoV-2 are nearly linked and sourced in bats, coronaviruses are naturally hosted by bats, and they're evolutionary.[2] The reservoir of MERS-CoV is unequivocally dromedary camels.[24]

Palm civets, racoon and dogs had been defined as intermediate hosts for zoonotic transmission of SARS-CoV among bats and human beings, but the SARS-CoV-2 intermediate host remains unclear.[25] proposing that upcoming zoonotic transmission incident may be continue which is related to repeated spillovers of coronaviruses in humans side by side to discovery of various coronaviruses in bats, including many SARS-linked coronaviruses (SARSr-CoVs).[24]

In 2002, SARS-CoV rised in Guangdong city of China and propagate to five continents via air travel ways, affecting 8,098 individuals also resulting in 774 deaths MERS-CoV rised in the Arabian Peninsula in 2012, where this remained the main public health problem, and was transmitted to 27 countries, affecting overall almost 2,494 persons and risking 858 souls.[26]

The coronavirus (CoV) currently called severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) which is responsible of coronavirus disease 2019 (COVID 19) and was revealed in Wuhan City in December 2019 in China. At first, COVID 19 disease was defined as a "pneumonia of unknown etiology" with high fever that was not reacting to drug medication and the early cases were engaged to the Huanan seafood market had been reported. Then, By January 2020 SARS-CoV-2 sequenced and isolated.27 The World Health Organization stated SARS-CoV-2 epidemic as a public health emergency of international concern On January 30, 2020.[28] As of March 3, 2020 COVID 19 pandemic has been affected over 90,000 people and killed more than 3,000 of those impacted in more than 60 countries.[29]

The way the SARS-CoV-2 is transported among humans is respiratory aerosols and close contact which were the main transmission ways.[30,6] Also, the transmission of SARS-CoV-2 by droplets is plausible under favorable conditions, particularly in relatively confined settings with poor ventilation and long duration exposure to high concentrations of aerosols.[31] Vertical transmission remains a subject of concern per researches including mothers delivering in both cesarian and normal delivery none of the neonates were tested positive for COVID 19. There are no published cases of clinical evidence of virus shedding in breast milk, vertical transmission are still to be discussed.[13,30,32] In a research it has been detected that 3 out of 33 neonates born from mothers positive to COVID 19 who were nasopharyngeal and rectal swabs COVID 19 positive. also fecal-oral transmission may be another transmission route due to positive stool sample has been detected even after COVID 19 was negative.[11,30]

Transmition by blood transfusion for the novel coronavirus disease 2019 (COVID 19) is not known yet, as long as there might be more people which are asymptomatic carriers or might donate blood, due to this it is crucial to realize whether the SARS-CoV-2 virus can be transmitted by blood transfusion or not. Although SARS-CoV-2 RNA had been detected in serum or plasma from infected patients, but there are no information and datas proposing the risk of transmission of SARS-CoV-2 by blood transfusion.[33] In a case study reported that in November 2019, a 21-year-old Korean male was diagnosed with serious aplastic anaemia, and gained transfusion of blood products from infected person who was not yet progressed signs and symptoms of COVID 19 and didn't lead to the disease. While the platelet of recipient was figured out with severe aplastic anaemia and was taking immunosuppressive medications.[4]

Transmissibility is determined using R0 which is the fundamental reproduction number, and is described as the number of additional persons one case infects over the course of their infection. If R0 is > 1, there's the possibility for sustained transmission. For two of SARS and MERS, R0 is < 1,4,5 whereas for COVID 19 the present rating is

much higher among 2.2 and 3.4 Therefore, it's potential that there's a greater risk from preoperative aerosols than with other diseases.[34,35]

### 1.4. Diagnosis

#### 1.4.1. Laboratory Diagnosis

In order to determine disease also monitering transmission quick and early laboratory diagnosis is crucial. RT-PCR is routine assuring examination doing by WHO as the gold standard analysis for SARS-CoV-2 diagnosis. SARS-CoV-2 positivity should be confirmed by molecular methods.[35] RT-PCR is suggested as a screening assay having positive PCR results, sequence analyses of positive amplicons can aid to assure the result and to differentiate between 2019-nCoV and other genetically closed coronaviruses (e.g., SARS coronavirus).[36] in plasma or lymphocytes coronaviruses RNA could be detected. For this reason, staff in blood centers and laboratories should progress biosafety protection during the epidemic.[37]

Crucial point in the laboratory examination of COVID 19 is through Suitable sample collection. Upper respiratory tract specimens, lower respiratory tract specimens, stool specimens, whole blood specimens, and serum specimens, and the respiratory secretions is the most frequently agreeable specimens for diagnosis. presently, SARS-CoV-2 has been figuerd out in nasopharyngeal swabs, oropharyngeal swabs, throat swabs, sputum, bronchoalveolar lavage fluid (BALF), whole blood, serum, stool, urine, saliva, rectal swabs and conjunctival swabs.[38]

Depending only on odd negative PCR outcome is hard to eliminate SARS-CoV-2 infection, particularly when diagnosis was used for upper respiratory tract samples. Also suspicious to positive chest computed tomography scans might offer negative outcomes for SARS-CoV-2 by reverse-transcriptase polymerase chain reaction (RT-PCR). For this reason, the reporting of nucleic acid analysis outcome have to be accurate also negative outcomes should not eliminate SARS-CoV-2.[39]

#### 1.4.2 Radiology

Utilizing of CT radiological outcomes to determine / scan COVID 19 is controversial and It was reported that CT results are not side of the testing standard to COVID 19 according to an American-Singaporean panel.[30]

Viral testing remains the only specific method of diagnosis as Centers for Disease Control (CDC) does not currently recommend CXR or CT to diagnose COVID 19. Assuring the viral test is required, even if radiologic findings are suggestive of COVID 19 on CXR or CT. For the initial diagnostic testing for suspected COVID 19 infection, the CDC suggests collecting and testing specimens from the upper respiratory tract (nasopharyngeal AND oropharyngeal swabs) or from the lower respiratory tract when available for viral testing.[40]

So as to study further the relation among ABO blood type and COVID 19 infection several review and studies was done about COVID 19 and ABO blood groups. The goal of this review is to investigate the division, correlation between the blood types and COVID 19 infection.

## 2. COVID 19 and BLOOD GROUP RELATION

In the meta-analysis study conducted by Golinelli et al., researchers tested odds of having every blood type between SARS-CoV-2 positive patients contrasted to controls. In their study, they did a scientific study on MEDLINE and LitCovid databases for studies published through July 15, 2020. There have been 7 researches match containment standards for meta-analysis, with a complete of 13 subgroups of populations (7503 SARS-CoV-2 positive cases and 2962160 controls) outcomes of their meta-analysis found that SARS-CoV-2 positive people were more likely to have blood group A (pooled OR 1.23, 95%CI: 1.09–1.40) and less likely to have blood group O (pooled OR = 0.77, 95%CI: 0.67–0.88).[18]

For analysing correlation among blood type and COVID 19, in a review researchers association from Europe and Australia stated outcomes of the research contrasting genome information from 1610 patients with intenise COVID 19 and 2205 healthy blood donors. In their study, whole participants were from Italy, Spain. Scientists figured out that gene variants in two sites of the human genome were related to severe COVID 19 and a higher risk of passing away from it. One amongst those sequences of DNA happens to hold the gene that deciedes blood group, and also the research discovered that, in contrast to individuals with other blood groups, those with group A had a 45% higher risk of promoting serious COVID 19 if infection, when individuals with group O had a 35% less risk.[42]

In an observational retrospective cohort study, scientists forwarded that ABO and Rh (D) blood groups don't seem to be accompanied with increasing or decreasing possibility of infection by SARS-CoV-2. Researchers were investigated 1,769 persons of airplane transporters staff, after which they undergo a physical testing and reverse transcriptase-polymerase chain reaction testing (RT-PCR). Results of observation illustrated that through the full staff, the ABO blood group exhibit a division of 39.9%, 10.8%, 4.1% and 44.0% for A, B, AB and O types, separately. The responding ratio for staff members infected with SARS-CoV-2 were 40.7%, 10.6%, 4.2%, and 43.2% for A, B, AB, and O types. In univariate diagnosis, no significant link was discovered among SARS-CoV-2 infection and ABO or Rh (D) groups.[43]

In a swedish study it was showed that blood group A or AB is contributed to higher risk of demanding crucial care or dying of COVID 19 within Swedish commuinty. In this study it was indicated that blood type A may be a risk agent for infection seriousness and passing away in COVID 19 regardless of the genetic context.[44]

In article published in April and updated in July, researchers used data from 7770 persons tested for SARS-CoV-2, 2206 of whom were checked positive for the virus the authors pooled their findings with data from China. In this study researchers found that through those with blood type, group B individual were more likely to check positive for SARS-CoV-2, and other people with group O were less likely to result positive. Yet, the data of study failed to provide solid evidence of a association among blood group and intubation or death through patients with COVID 19.[45]

In Latz et al. project which they are defininig whether if there is a relationship among ABO blood group and severity of COVID 19 determined by intubation or death as well as assuring if there is changinility in checking positive for COVID 19 through blood groups, tested 1289 patients who checked positive. Distribution of patients according to their blood groups type was 440 (34.2%) were A blood group, 201 (15.6%) were B blood group, 61 (4.7%) were AB blood group, and 587 (45.5%) were O blood group. According to their study results, blood group was not distinctly contributed with risk of intubation or passing away. A blood group had no association with positive diagnosis, B blood group was contributed with rised odds of checking positive for infection, AB blood type was also contributed with higher odds of checking positive, and O blood type was related with a lower risk of checking positive. Rh positive case was linked with higher odds of checking positive. Blood group was not correlated with risk of intubation or death in patients with COVID 19. Patients with B and AB blood groups who obtained an examination were more likely to check positive and O blood group was less likely to result positive. Rh positive patients were more likely to result positive.[10]

In study at the University of Cincinnati researchers tested the linkage of blood group and rhesus related hospitalization also infection seriousness between 428 COVID 19 patients examinied. In samples, 50.2% of participants had the O blood group, 38.7% had the A blood group, 17.5% had the B blood group, and 3.5% had the AB blood group.

In analyzation setted for sociodemographic cretiria and comorbidities, the blood groups A, B, AB, and O were not correlated with hospitalization for COVID 19. Identically, the A, B, AB, and O blood groups weren't correlated with admitting to intensive care unit or passing away in COVID 19. To conclude researchers stated that blood group is not correlated with hospitalization or disease seriousness in COVID 19.[45]

In a research at the Presbyterian hospital in New York 14,112 COVID 19 tested patients with known blood type were examined. It was discovered lightly raised infection propagation through non-O blood groups. risk of intubation was falln through blood type A and raised through AB and B blood groups, in contrast with blood type O, whereas risk of passing away was raised for AB blood type and reduced for A and B blood groups. Researchers assessed that Rh (-) blood group to have a defensive impact to whole 3 results. The results of the study adding evidence claiming that blood group may take part in COVID 19.[46]

In a study done to examine the relation among ABO histo-blood type phenotypes and COVID 19, researchers found ABO histo-blood phenotypes are associated with patients' sensitivity to the disease. A higher ratio of disease was noted through patients with the AB histo-blood type, while patients with the O histo-blood type have clarify lower ratio of infection. Also the Rh blood type phenotype wasn't statistically significant in defining patient's vulnerability.[47]

In the study performed in Sudan were concluded higher rate of women were infected compared to men, and people among 25 and 35 years old were the most influenced age group. Blood type O Rhesus-positive (O+) was the less influenced by the infection while A Rhesus positive (A+) blood type individuals were the most vulnerable. The researchers thought that the potentially low incidence of COVID 19 in the country may be due to the Sudanese population being largely composed of O Rhesus-positive residents (about 50%).[48]

In a study at Hacettepe University School of Medicine Hospitals, The most recurrent detected blood type was A blood type (57%) and type O (24.8%) through the COVID 19 patients. The A blood type was statistically significantly more recurrent through those infected with COVID 19 in contrast to controls (57% vs. 38%, P < 0.001; OR: 2.1). On the other side, the recurrence of O blood type was significantly lower in the COVID 19 patients, in contrast to the control group (24.8% vs. 37.2%, P: 0.001; OR: 1.8). When clinical outcomes are determined according to blood groups, the blood group types was not affected the clinical resultes.[49]

## 3.CONCLUSION

Relationship between COVID 19 and blood types with features such as clinical outcomes, length of stay in the hospital / intensive care unit, intubation status and survival / death of COVID 19 patients had examined in many studies (Table 1).

According to the researches took apart in this review, it can be argued that group A blood type might be on the higher risk in comparison to other blood groups where is blood type O took the lowest risk of the infection.

Many studys claimed that ABO blood types are relatively just contributed with risk varieties of COVID 19. One possible mechanism which will be taking part with raising risk connected to blood type antigen A is that it contains a galactose as end group saccharide. two blood groups B and O have a galactose amine in this site, and this could clarify the difference amongst blood types. The spike protein of SARS-COV-2 has been shown to bind carbohydrates, and a strong affinity among the A antigen and also the virus could aid in uptaking of the virus into the cells, Also other previous research estimated that although ABO blood group and/or cardiovascular diseases are sign of the seriosity of COVID 19 in patients, they're not agents predispo-

sing to the risk of gaining SARS-CoV-2 infection, there's a pathophysiological mechanism to support this estimation: subjects that A blood type are at risk of the expantion of cardiovascular diseases and severe COVID 19 due to positive correlation of this blood type with angiotensin-converting enzyme action, and therefore the binding of adhesion molecules on the vascular wall, which rise and reduce the inflammation.[42,43]

Suprisingly, while observing a reduced vulnerability to the infection between patients with an O histo-blood type, discordant results have been obtained reffering the raised possibility through people with an AB histo-blood type, unlike A histo-blood type in the past research.[47] study results show epidemiological proofs that women with blood group A were sensibile to COVID 19.[48]

In research evaluating clinical outcomes (i.e intubation or death/survival) in blood group and COVID 19 disease, it was found that the blood type was not contributed to the risk developing to serious infection demanding intubation or resulting in passing, nor was it correlated to increased status of inflammatory sign.[44] Yet, In a study investigating the Genome-Wide Relationship of Severe COVID 19 with Respiratory Failure, researchers descovered a 3p21.[31] Gene clump as a genetic sensibility site in patients with COVID 19 with respiratory failure and stated a potential involvement of the ABO blood-type system.[53] In another research, risk intubation was reduced amongst A and raised amongst types AB and B, in contrast to O group, wheareas risk of passing away was raised for type AB and reduced for types A and B. Also, reserchers guessed that Rh (-) blood group to have defensive impact for whole 3 results, the high COVID 19 infection epidemiology, severe infection and the need for intubation.[10]

In a research studying the connection among sociodemographic characteristics, comorbid factors and blood groups and COVID 19, sociodemographic cretiria and comorbidities, the blood groups A, B, AB, and O weren't correlated with hospitalization for COVID 19. Likewise, the blood groups A, B, AB, and O weren't correlated with submission to intensive care unit or passing away in COVID 19.[45]

However, there are several studies and researches showing that there is no significant difference among blood group and COVID 19 risk.[42]

Under the light of these researches and review, we can say that it is yet to be investigated whether if there is a correlation or significant difference among the ABO blood type and COVID 19 becauseconcept that blood type may have importance impact on COVID 19 is interesting. Wrapping it up, our present information propose that A blood type might be a risk factor for COVID 19 linked crucial disease between white patients, and that O blood type might be defensive. Future investigations are needed to determine the mechanisms for these outcomes.

**Table 1:** Explaing all the research article related to Blood group system and COVID 19.

| Study | Study type | Study features | A | B | AB | O | Rh + | Rh - |
|---|---|---|---|---|---|---|---|---|
| Abdollahi et al.[48] | Original Article, cross-sectional survey | N=397 | 160 (40.3%) | 89 (22.4%) | 37 (9.3%) | 111 (28%) | 357 (89.9%) | 40 (10.1%) |
| | | ICU (n=127) | 51 (40.2%) | 28 (22%) | 10 (7.9%) | 38 (29.9%) | 117 (92.1%) | 10 (7.9%) |
| | | General wards (n=270) | 109 (40.4%) | 61 (22.6%) | 27 (10%) | 73 (27%) | 240 (88.9%) | 30 (11.1%) |
| Zietz et al.[14] | Article, Descriptive cohort | N=14.112 | 4298 (32.9) | 2033 (15.6) | 559 (4.3) | 6161 (47.2) | 11,856 (90.8) | 1195 (9.2) |
| | | Descriptive cohort study | 58 (37–72) | 57 (37–72) | 57 (37–71) | 55 (36–71) | 56 (37–71) | 56 (37–70) |
| | | Male (%) | 1676 (39.0) | 778 (38.3) | 231 (41.3) | 2339 (38.0) | 4594 (38.7) | 430 (36.0) |
| | | COV+ Intubated (%) | 111 (2.6) | 78 (3.8) | 17 (3.0) | 193 (3.1) | 375 (3.2) | 24 (2.0) |
| | | COV+Died (%) | 104 (2.4) | 46 (2.3) | 15 (2.7) | 166 (2.7) | 320 (2.7) | 11 (0.9) |
| Taha et al.[49] | Original Article, case–control study | N=557, Susceptibility towards infection with COVID 19 | 180 (32.3) | 102(18.3) | 34 (6.1) | 241 (43.2) | 511 (91.7) | 46 (8.2) |
| Mendy et al.[46] | Original Article cross-sectional research | N=428 | 123 | 75 | 15 | 215 | 400 | 28 |
| | | cross-sectional research | 37.4 | 42.7 | 33.3 | 35.8 | - | - |
| | | Age, years, median (SE) | 50.5 (2.8) | 49.5 (3.3) | 44.0 (8.7) | 38.9 (1.3) | - | - |
| | | Hospitalization n: 192 | 56 | 34 | 5 | 97 | 178 | 14 |
| | | Severe COVID 19 n: 115 | 28 | 18 | 15 | 54 | 94 | 7 |
| | | Admission ICU % | 20.3 | 20.0 | 6.7 | 23.3 | - | - |
| | | Death, % | 10.6 | 6.7 | 0.0 | 6.5 | - | - |
| Latz et al.[10] | Original Article, Retrospective study | N=1289 | 440 | 201 | 61 | 587 | - | - |
| | | Retrospective study | 56.9 (18.6) | 57.6 (18.1) | 57.1 (19.9) | 54.8 (18.1) | - | - |
| | | Female sex | 299 (68.0%) | 136 (67.7%) | 33 (54.1%) | 404 (68.8%) | - | - |
| | | Admitted | 158 (35.9%) | 85 (42.3%) | 28 (45.9%) | 213 (36.3%) | - | - |
| | | ICU admission | 41 (9.3%) | 18 (9.0%) | 7 (11.5%) | 57 (9.7%) | - | - |
| | | Dead | 36 (8.2%) | 14 (7.0%) | 5 (8.2%) | 34 (5.8%) | - | - |
| Göker et al.[50] | Research Article, Cross-sectional case–control study | Cases N=186 | 106 (57) | 20 (10.8) | 14 (7.5) | 46 (24.8) | 160 (86) | 26 (14) |
| | | Male sex, % | 58 | 9 | 8 | 25 | 85 | 15 |
| | | Age (median) | 43 (19–84) | 48 (26–92) | 33.5 (20–64) | 41 (23–84) | 41.5 (19–92) | 47 (20–73) |
| | | ICU ( n/%) | 17 (16) | 3 (15.8) | 4 (28.6) | 7 (15.2) | 25 (15.7) | 6 (23.1) |
| | | Intubation ( n/%) | 7 (6.6) | 0 | 1 (7.1) | 3 (6.5) | 9 (5.7) | 2 (7.7) |
| | | Dead ( n/%) | 6 (5.7) | 2(10) | 0 | 1 (2.2) | 8 (5) | 1 (3.8) |
| Fan et al.[6] | Original Article, Case–control study | Case N=105 | 45 (42.8%) | 28 (26.7%) | 9 (8.57%) | 23 (21.9%) | - | - |
| | | Case–control study | 21 | 17 | 6 | 11 | - | - |
| Boudin et al.[43] | Letters to editor | Confirmed/suspected SARS-CoV-2 N=1279 (76.0) | 521 (40.7) | 135(10.6) | 54(4.2) | 553(43.2) | 1092 | 171 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Golinelli et al.[18] | Systematically research, Multicenter study | Wuhan Jinyintan Hospital N=1775 | 670 (37.75%) | 469 (26.42%) | 178 (10.03%) | 458 (25.80%) | - | - |
| | | Death= 206 | 85 (41.26%) | 50 (24.27%) | 19 (9.22%) | 52 (25.24%) | - | - |
| | | Renmin Hospital of Wuhan University N=113 | 45 (39.82%) | 25 (22.12%) | 15 (13.3%) | 28 (24.78%) | - | - |
| Li et al.[55] | Case-control Controls study and Multicenter study | Central Hospital of Wuhan N= 265 | 104 (39.3) | 67 (25.3) | 26 (9.8) | 68 (25.7) | - | - |
| | | Male sex, % (n = 113) | 48 (42.5) | 30 (26.6) | 9 (8.0) | 26 (23.0) | - | - |
| | | Less than 40 years (n = 69) | 24 (34.8) | 17 (24.6) | 8 (11.6) | 20 (29.0) | - | - |
| | | Between 41–59 years (n = 79) | 29 (36.7) | 20 (25.3) | 8 (10.1) | 22 (27.9) | - | - |
| | | Over 60 years (n = 117) | 51 (43.6) | 30 (25.6) | 10 (8.6) | 26 (22.2) | - | - |
| | | Deaths (n = 57), % | 20 (35.1) | 15 (26.3) | 8 (14.0) | 14 (24.6) | - | - |
| | | Three Wuhan Hospitals N=2153 | 819 (38.0) | 561 (26.1) | 219 (10.2) | 554 (25.7) | - | - |
| | | Less than 40 years (n = 342) | 124 (36.3) | 95 (27.8) | 29 (8.5) | 94 (27.5) | - | - |
| | | Between 41–59 years (n = 784) | 304 (38.8) | 196 (25.0) | 79 (10.1) | 205 (26.2) | - | - |
| | | Over 60 years (n = 1027) | 391 (38.1) | 270 (26.3) | 111 (10.8) | 255 (24.8) | - | - |
| | | Male (n = 1143) | 451 (39.5) | 305 (26.7) | 110 (9.6) | 277 (24.2) | - | - |
| Wu et al.[51] | Retrospective study, Case-control | Cases N=187 | 69(36.90) | 63(33.69) | 14(7.49) | 41(21.92) | - | - |
| | | Age <40 | 22(31.88) | 25(39.68) | 14(34.15) | 8(57.14) | - | - |
| | | Age ≥40 | 47(68.12) | 38(60.32) | 27(65.85) | 6(42.86) | - | - |
| | | Male sex | 35(50.72) | 33(52.38) | 22(53.66) | 7(50.00) | - | - |
| Ellinghaus et al.[54] | N: 1980 Cases:835 Controls:1255 | Italian Hospitals Cases N = 835 | 46.5% | 10.9% | 5.1% | 37.5% | - | - |
| | | Spanish Hospitals: Cases N= 775 | 48.6% | 9.2% | 4.6% | 37.5% | - | - |
| Leaf et al.[53] | Cohort study, Multicentre | N = 2033 (100%) | 666 (32.7%) | 328 (16.1%) | 89 (4.4%) | 950 (46.7%) | - | - |
| | | Male sex, n (%) | 417 (62.6) | 189 (57.6) | 58 (65.2) | 633 (66.6) | - | - |
| | | Age, years, median (IQR) | 64 (53–72) | 63 (54–71) | 66 (56–72) | 61 (50–70) | - | - |
| | | Invasive mechanical ventilation, n (%) | 466 (70.0) | 238 (72.6) | 71 (79.8) | 663 (69.8) | - | - |
| | | | 268 (40.2) | 129 (39.3) | 41 (46.1) | 361 (38.0) | - | - |

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