rs12329760 Polymorphism in Transmembrane Serine Protease 2 Gene and Risk of Coronavirus Disease 2019 Mortality

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The protease produced by the transmembrane serine protease 2 (TMPRSS2) gene enhances viral infections and has been linked to severe acute respiratory syndrome coronavirus 2 pathogenesis. Therefore, this study evaluated the association between TMPRSS2 and coronavirus disease 2019 (COVID-19) mortality. TMPRSS2 rs12329760 polymorphism was genotyped using the tetraprimer amplification refractory mutation system-polymerase chain reaction method in 592 dead and 693 improved patients. In the current study, the frequency of TMPRSS2 rs12329760 CC than TT genotypes was significantly lower in improved patients than in dead patients. According to the findings of the multivariate logistic regression test, higher levels of mean age, creatinine, erythrocyte sedimentation rate, C-reactive protein, aspartate aminotransferase, lower levels of 25-hydroxyvitamin D, uric acid, and real-time PCR Ct values and TMPRSS2 rs12329760 CC genotype were observed to be associated with increased COVID-19 mortality rates. In conclusion, the TMPRSS2 rs12329760 CC genotype was a polymorphism linked to a significantly higher incidence of severe COVID-19. Further studies are required to corroborate the obtained findings.

1. Introduction

A novel coronavirus known as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was identified as the source of a cluster of pneumonia cases in Wuhan, China, at the end of 2019. The virus soon spread throughout the world, triggering a global pandemic of a sickness known as coronavirus disease 2019 (COVID-19) by the World Health Organization (WHO) [1]. Angiotensin-converting enzyme 2 is the host receptor that SARS-CoV-2 binds to (ACE2). In the past, a number of approaches to creating a vaccine against SARS-CoV-2 or MERS-CoV have been tested with varying degrees of success. Since SARS-CoV-2 enters the host cell using the spike (S) protein, it is one of the most popular targets for developing vaccines or treatments for SARS-CoV-2. Efforts are underway to develop a drug to combat the COVID-19 infection. It has been shown in a study that JMX0286, JMX0301, and JMX0941 are the three compounds that are effective allosteric inhibitors of SARS-CoV-2 3CLpro [2, 3].

It has been demonstrated that the effectiveness of three novel oral antivirals (molnupiravir, fluvoxamine, and paxlovid) in lowering the mortality and hospitalization rates in COVID-19 patients. The three oral medications also showed satisfactory overall safety by not increasing the frequency of adverse events. These three oral antiviral medications are still being researched, but the information that is now available indicates that they will offer new hope for COVID-19
recovery and have the potential to be a breakthrough and very promising treatment for COVID-19 [4].

There are several established risk factors related to increased COVID-19 morbidity and mortality, including age, to a lesser extent male gender, and a variety of underlying clinical disorders, such as obesity, diabetes, and cardiovascular disease [5]. The importance of host genetic factors has lately surfaced as a new, although still poorly understood, risk factor for COVID-19. Genome-wide association studies (GWAS) have identified genetic haplotypes spanning in numerous genes that are linked to the severity of COVID-19 [6].

It has been recently demonstrated that SARS-CoV-2 utilizes the angiotensin-converting enzyme 2 (ACE2) receptor for host cell attachment, and the viral spike (S) protein is cleaved into S1 and S2 by transmembrane serine protease 2 (TMPRSS2) to allow membrane fusion between the viral and cellular membranes. Because the ACE2 and TMPRSS2 are highly expressed in a variety of organs, including the respiratory system, lung, heart, kidney, and gastrointestinal tract, it has been hypothesized that their widespread distribution might increase vulnerability to SARS-CoV-2 infection [7, 8].

There are 496 noncoding genetic and 520 coding genetic variations in the TMPRSS2 gene (chr21:42836478-42). Only small percentages of the TMPRSS2 SNPs were nonsynonymous and had extremely low minor allele frequencies. Of these, 43 SNPs were classified as loss of function (MAF) [9]. There are two nonsilent variations (TMPRSS2 rs12329760; c.589G > A p.Val160Met and TMPRSS2 rs75603675; c.23G > T p.Gly8Val) with varying frequencies among the 13 common single-nucleotide polymorphisms (SNPs) within the TMPRSS2 gene (0.0096 to 0.4 for rs75603675 and 0.172 to 0.385 for rs12329760) [10]. The TMPRSS2 rs17854725 SNP is a synonymous variant that replaces two isoleucine codons at position 256 [11].

TMPRSS2 SNPs have been correlated with H1N1 or H1N9 influenza virus infection susceptibility and severity [12]. At the moment, SNPs that affect gene expression or protein function are often discussed in the context of COVID-19 in literature reviews and in silico investigations based on genotyping data from existing databases [13, 14].

Due to its functional significance, the missense variant rs12329760, which changes the amino acid valine at position 160 to methionine, might be of importance in the context of COVID-19 [15]. The rs12329760 T-allele is linked to the numerous copies of the TMPRSS2-ERG gene fusion, which is linked to poorer survival and greater tumor recurrence in prostate cancer [16].

Based on the aforementioned connections, this study examined the effect of the TMPRSS2 variation rs12329760 on the probability of SARS-CoV-2 infection and the COVID-19 mortality rate in Iranian patients.

2. Materials and Methods

2.1. Study Participants. The present study was conducted with the approval of the Ethics Committee of Pasteur Institute of Iran (IR IIIEC 1400.042). The study participants provided written informed consent.

Enrollment started on May 11, 2020, and ended on January 28, 2022. The patients were considered SARS-CoV-2 positive if at least one real-time reverse transcription polymerase chain reaction (real-time RT-PCR) result was positive. In total, 1,285 COVID-19-positive patients were included in this study according to exclusion criteria, such as human immunodeficiency virus (HIV), cancer, chronic kidney disease, heart disease, pregnancy, diabetes, liver disease, cystic fibrosis, asthma, chronic obstructive pulmonary disease, and obesity. All samples of patients were collected from one hospital in a city with the same ethnic group that was the inclusion criteria.

All clinical parameters of the patients were examined as soon as they were referred to the hospital. The clinical parameters, including real-time PCR cycle threshold (Ct) values, 25-hydroxyvitamin D, erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), platelets, white blood cells (WBC), triiodothyronine (T3), thyroxine (T4), thyroid-stimulating hormone (TSH), alkaline phosphatase (ALP), aspartate aminotransferase (AST), alanine aminotransferase (ALT), high-density lipoprotein (HDL), low-density lipoprotein (LDL), triglyceride (TG), cholesterol, fasting blood glucose (FBG), uric acid, and serum creatinine, were extracted from the patients’ medical records.

2.2. DNA Extraction and TMPRSS2 rs12329760 Genotyping. Genomic DNAs were extracted from peripheral blood mononuclear cells (PBMCs) using High Pure PCR Template Preparation Kit (Roche Diagnostics Deutschland GmbH, Mannheim, Germany), according to the manufacturer’s instructions.

We designed the tetraprimer amplification refractory mutation system-polymerase chain (T-ARMS–PCR) method for genotyping of the TMPRSS2 rs12329760 polymorphism. The primers of TMPRSS2 rs12329760 were designed using the PRIMER1 website (http://primer1.soton.ac.uk/primer1.html). The primer sequences were then evaluated for heterodimers, self-dimers, GC content, and hairpins using the oligo-analyzer. For facilitating reliable discrimination between two alleles, the mismatched nucleotide was added at the third position from the 3’-end terminal of the primers (Table 1).

The PCR was carried out in a 20 μL reaction volume containing 10 μL TempStart Hot Start DNA Polymerase (Ampliqon, Hamburg, Germany), 50 ng of genomic DNA, 1.0 μL of 10 pmol of outer forward primer, 2.5 μL of 10 pmol of outer reverse primer, 2.5 μL of 10 pmol of inner forward primer, and 1.0 μL of 10 pmol of inner reverse primer. Amplification was performed using the PCR conditions 95°C for 20 minutes, followed by 38 cycles of 95°C for 35 seconds, annealing at 62°C for 30 seconds and 72°C for 35 seconds, followed by final extension at 72°C for 10 minutes. The PCR amplicons were analyzed on 1.5% agarose gel (Supplementary Figure 1).

For the assessment of the efficiency and accuracy of the assay, DNA sequencing by ABI 3500 DX Genetic Analyzer (ABI, Thermo Fisher Scientific, Waltham, MA, USA) was
performed on a subset of PCR-amplified samples, and the results of T-ARMS-PCR were compared to those obtained by sequencing (Supplementary Figure 2).

2.3. Statistical Analyses. The chi-square ($X^2$) test was utilized to assess the frequency of TMPRSS2 rs12329760 genotypes in dead and improved patients. Additionally, the Mann-Whitney U test was employed to evaluate the data for continuous variables. Multiple logistic regression models were employed to determine the association of genotypes, allele frequencies, and other variables with the possibility of COVID-19. The odds ratio (OR) and the accompanying 95% confidence interval (CI) were calculated. The effect of TMPRSS2 rs12329760 on COVID-19 mortality was determined using the area under the receiver operating characteristic curve (AUC-ROC) analysis. All the tests were two sided, and a $P$ value $<0.05$ was considered statistically significant. The calculations were performed using IBM SPSS version 22.0. (SPSS Inc., Chicago, IL, USA). The inheritance mode analysis in SNPStats software was applied to assess the association between COVID-19 mortality and TMPRSS2 rs12329760. The Akaike information criterion (AIC) and Bayesian information criterion (BIC) were used to choose the model with the greatest match for each SNP. The $X^2$ test was employed to assess the Hardy-Weinberg equilibrium (HWE) for genotype distributions [17].

3. Results

3.1. Demographic Characteristics of COVID-19 Patients. Table 2 shows the demographic information of COVID-19 patients. The current study included 1,285 patients with COVID-19, 592 and 693 of whom were in the dead and improved groups, respectively. The mean ($\pm$SD) age values of dead and improved patients were 58.0 $\pm$ 11.4 and 51.7 $\pm$ 12.8 years, respectively. In this study, 677 (52.7%) and 608 (47.3%) were male and female, respectively. The mortality of the disease increased with mean ($\pm$SD) age ($P < 0.001$); high levels of $Cr$ ($P < 0.001$), FBS ($P < 0.001$), ALP ($P < 0.001$), ALT ($P < 0.001$), AST ($P < 0.001$), ESR ($P < 0.001$), and CRP ($P < 0.001$); and lower levels of cholesterol ($P < 0.001$), TG ($P = 0.001$), LDL ($P < 0.001$), HDL ($P < 0.001$), 25-hydroxyvitamin D ($P < 0.001$), real-time PCR Ct value ($P = 0.011$), and uric acid ($P < 0.001$).

3.2. Correlation between TMPRSS2 rs12329760 and COVID-19 Mortality. Figure 1 shows the effect of TMPRSS2 rs12329760 on COVID-19 infection mortality. The patients with TMPRSS2 rs12329760 CC genotypes demonstrated significantly higher COVID-19 infection mortality than individuals with other genotypes; nevertheless, COVID-19-recovered patients had TT genotypes (Figure 1(a)).

The TMPRSS2 rs12329760 inheritance model, including codominant, dominant, recessive, and overdominant, was generated using SNPStats software. For TMPRSS2 rs12329760, the best-fitting inheritance model was codominant with the lowest AIC and BIC values. A higher risk of death was associated with the CC genotype.

TMPRSS2 rs12329760 genotypes were compatible with HWE in improved ($P = 0.570$) and dead ($P = 0.281$) patients. MAF (T-allele) in improved, dead, and all patients was 0.37, 0.07, and 0.23, respectively (Table 3).

Furthermore, the AUC-ROC values for TMPRSS2 rs12329760 were 0.708, indicating that host genetic variables frequently contribute to viral infection mortality (Figure 1(b)).

3.3. Risk Factors Linked to COVID-19 Mortality. This study examined several parameters linked with COVID-19 infection mortality using multivariate logistic regression analysis. The mortality of COVID-19 infection was correlated with mean age ($OR 0.975, 95\% CI 0.958-0.993, P = 0.006$), HDL ($OR 1.046, 95\% CI 1.025-1.066, P < 0.001$), LDL ($OR 1.024, 95\% CI 1.019-1.030, P < 0.001$), uric acid ($OR 2.043, 95\% CI 1.768-2.361, P < 0.001$), creatinine ($OR 0.074, 95\% CI 0.038-0.145, P < 0.001$), ESR ($OR 0.965, 95\% CI 0.951-0.979, P < 0.001$), CRP ($OR 0.973, 95\% CI 0.963-0.984, P = 0.004$), 25-hydroxyvitamin D ($OR 1.057, 95\% CI 1.038-1.077, P < 0.001$), AST ($OR 0.983, 95\% CI 0.973-0.992, P < 0.001$), real-time PCR Ct values ($OR 0.961, 95\% CI 0.932-0.991, P = 0.011$), and TMPRSS2 rs12329760 CC ($OR 16.723, 95\% CI 10.841-25.798, P < 0.001$) (Table 4).

4. Discussion

This comprehensive study was performed in Iran to evaluate a possible correlation between TMPRSS2 rs12329760 polymorphism with the susceptibility of SARS-CoV-2 acquisition and disease progression. To date, most in silico reports have conducted to investigate the impact of polymorphisms in the TMPRSS2 gene on COVID-19 [13, 18]. In a pilot study conducted on a small scale, the TMPRSS2 rs12329760 T-allele carriers’ frequency was significantly lower in Italian SARS-CoV-2-positive patients than in a European reference group from the Gnom Aggregation Database (GnomAD) [19]. Interestingly, a significant higher prevalence of T-allele carriers was observed.
in dead patients (0.07) than in improved patients (0.37). The allele frequency of TMPS22 rs12329760 in this study is 0.23. This value is equal to the one reported in GnomAD for East Asia (0.38), Finns (0.37), Estonia (0.31), Sweden (0.29), and Africans (0.29) [20]. This would be reasonable if it is assumed that T-allele carriers express more genes that could result in increased TMPS22 activity leading to increased infection susceptibility [15].

The TMPS22 rs12329760 polymorphism was categorized as deleterious based on the data collected from computational research utilizing Sorting Intolerant From Tolerant (SIFT), screening for nonacceptable polymorphisms (SNAP2), PolyPhen-2, and PROVEAN [21]. This was due to the fact that splice variants resulting from genetic variations in TMPS22 have modified the expression of TMPS22, altering susceptibility to infection with SARS-CoV-2 [22]. According to bioinformatics studies (ConSurf), the mutation (rs12329760) might impair the TMPS22 protein’s stability. Protein stability has an effect on the functional and structural activities of a protein. Any alteration in protein stability results in misfolding or abnormal protein structure [23].

Furthermore, because extremely damaging nonsynonymous SNPs have high conservation scores, evolutionary conservation analysis in the protein sequence is required to evaluate whether a mutation is null or has any effect on the protein [24]. The results of ConSurf revealed that the variant is located in conserved regions; therefore, it might increase the probability of COVID-19 infection by downregulating TMPS22 [25]. The p.V160M mutation may alter the function of TMPS22 gene. A role in ligand and/or protein interaction has been hypothesized for the scavenger receptor cysteine rich (SRCS), which is a highly conserved domain whose function is not entirely understood. It is interesting to note that various proteins involved in host defense, including cluster of differentiation 5 (CD5), CD6, and complement factor I, contain this domain, therefore increasing the probability that the TMPS22 rs1239760 role in COVID-19 infection may extend beyond its peptidase activity associated with viral protein priming [26, 27]. Molecular dynamics modeling confirms structural distortions caused by a full shift in the motif, resulting in changes in the protein’s quaternary structure and a concurrent rise in B factor with the V160M variation. Although the V160M is not positioned in the catalytic pocket of TMPS22, a decrease in protein stability may hinder SARS-CoV-2 viral entry; nevertheless, this needs to be validated [27].

In this study, higher risk of death was associated with the TMPS22 rs1239760 CC genotype than with other ones. In line with the aforementioned finding, a meta-

Table 2: Comparison laboratory parameters between dead and improved patients infected with COVID-19.

| Variables                     | Dead patients (n = 592) | Improved patients (n = 693) | P value |
|-------------------------------|------------------------|-----------------------------|---------|
| Mean age ± SD                 | 58.0 ± 11.4            | 51.7 ± 12.8                 | <0.001* |
| Gender (male/female)          | 315/277 (53.2/46.8%)   | 362/331 (52.2/47.8%)        | 0.728   |
| ALT (IU/L) (mean ± SD) (range: 5-40) | 44.4 ± 23.9           | 33.1 ± 24.1                 | <0.001* |
| AST (IU/L) (mean ± SD) (range: 5-40) | 37.0 ± 13.1           | 31.2 ± 15.6                 | <0.001* |
| ALP (IU/L) (mean ± SD) (range: Up to 306) | 202.1 ± 66.1          | 169.3 ± 90.1                | <0.001* |
| Cholesterol (mg/dL) (mean ± SD) (range: 50-200) | 116.7 ± 39.7          | 122.2 ± 36.3                | <0.001* |
| TG (mg/dL) (mean ± SD) (range: 60-165) | 116.2 ± 41.5          | 132.0 ± 41.7                | 0.001*  |
| LDL (mg/dL) (mean ± SD) (range: up to 150) | 69.8 ± 32.2           | 107.6 ± 49.3                | <0.001* |
| HDL (mg/dL) (mean ± SD) (range: >40) | 30.7 ± 10.9           | 34.3 ± 11.6                 | <0.001* |
| WBC (10^3/L) (mean ± SD) (range: 4000-10000) | 7544.1 ± 2655.9       | 7718.8 ± 2894.1             | 0.506   |
| CRP (mg/L) (mean ± SD) (reference range: <10 mg/L negative) | 67.5 ± 21.4           | 56.8 ± 20.8                 | <0.001* |
| ESR (mm/1st h) (mean ± SD) (range: 0-15) | 55.5 ± 15.5           | 46.5 ± 15.4                 | <0.001* |
| FBS (mg/dL) (mean ± SD) (range: 70-100) | 111.0 ± 43.4          | 105.6 ± 41.3                | <0.001* |
| Platelets × 1000/cumm (mean ± SD) (reference range: 140000-400000) | 185 ± 77              | 183 ± 66                    | 0.587   |
| Uric acid (mg/dL) (mean ± SD) (range: 3.6-6.8) | 3.7 ± 1.2             | 5.7 ± 1.6                   | <0.001* |
| Creatinine (mg/dL) (mean ± SD) (range: 0.6-1.4) | 1.1 ± 0.3             | 0.8 ± 0.3                   | <0.001* |
| T3 (ng/dL) (mean ± SD) (range: 2.3-4.2) | 3.1 ± 1.2             | 2.5 ± 0.8                   | 0.062   |
| T4 (mcg/dL) (mean ± SD) (range: 5.6-13.7) | 8.9 ± 4.1             | 8.3 ± 3.8                   | 0.222   |
| TSH (mu/L) (mean ± SD) (range: 0.4-4.5) | 3.4 ± 1.7             | 3.2 ± 1.5                   | 0.557   |
| 25-hydroxy vitamin D (ng/mL) (mean ± SD) (sufficiency: 21-150) | 26.9 ± 10.2           | 35.9 ± 13.6                 | <0.001* |
| Real-time PCR Ct values        | 12.8 ± 7.0            | 26.6 ± 8.1                  | 0.011*  |

ALT: alanine aminotransferase; AST: aspartate aminotransferase; ALP: alkaline phosphatase; TG: triglyceride; LDL: low-density lipoprotein; HDL: high-density lipoprotein; WBC: white blood cells; CRP: C-reactive protein; ESR: erythrocyte sedimentation rate; FBS: fasting blood glucose; T3: triiodothyronine; T4: thyroxine; TSH: thyroid-stimulating hormone; Ct: cycle threshold; SD: standard deviation. *Statistically significant (<0.05).
analysis study has shown that COVID-19 patient with TMPRSS2 rs12329760 CC genotype compared to individuals with CT and TT genotypes had a 1.79-fold greater chance of getting infectious symptoms (moderate to severe) [28]. The detailed analysis of the COVID-19 Host Genetic Initiative (HGI) data revealed an important link between the TMPRSS2 rs12329760 polymorphism and disease severity [29, 30]. The first whole-genome investigation in 322 Chinese patients infected with COVID-19 revealed a decreased allele frequency of the TMPRSS2 rs12329760 variant in patients with severe disease than patients with moderate disease, demonstrating the critical role of TMPRSS2 in progression of

| Model          | Genotype | Groups                                      | OR (95% CI) | P value | AIC     | BIC     |
|----------------|----------|---------------------------------------------|-------------|---------|---------|---------|
| Allele         | C        | Improved patients (n = 693)                 |             |         |         |         |
|                | T        | Dead patients (n = 592)                     |             |         |         |         |
| Codominant     | C/C      | 270 (39.0%)                                 | 513 (86.7%) | 1.00    |         |         |
|                | C/T      | 331 (47.8%)                                 | 70 (11.8%)  | 0.11 (0.08-0.15) | <0.0001 | 1448.8  1469.5 |
|                | T/T      | 92 (13.3%)                                  | 9 (1.5%)    | 0.05 (0.03-0.10) |         |         |
| Dominant       | C/C      | 270 (39.0%)                                 | 513 (86.7%) | 1.00    | <0.0001 | 1451.8  1467.3 |
|                | C/T-T/T  | 423 (61.0%)                                 | 79 (13.3%)  | 0.10 (0.07-0.13) | <0.0001 | 1451.8  1467.3 |
| Recessive      | C/C-C/T  | 601 (86.7%)                                 | 583 (98.5%) | 1.00    | <0.0001 | 1707.3  1722.8 |
|                | T/T      | 92 (13.3%)                                  | 9 (1.5%)    | 0.10 (0.05-0.20) | <0.0001 | 1707.3  1722.8 |
| Overdominant   | C/C-T/T  | 362 (52.2%)                                 | 552 (88.2%) | 1.00    | <0.0001 | 1573.5  1598.0 |
|                | C/T      | 331 (47.8%)                                 | 70 (11.8%)  | 0.15 (0.11-0.20) | <0.0001 | 1573.5  1598.0 |

Minor allele frequency (T) 0.37 0.07 —         —         —         —

OR: odds ratios; CI: confidence intervals; AIC: Akaike information criterion; BIC: Bayesian information criterion.
Table 4: Factors associated with dead patients infected with COVID-19.

| Factors               | Baseline predictors | OR (95% CI) | P value |
|-----------------------|--------------------|-------------|---------|
| Mean age ± SD         | 0.975 (0.958-0.993) | 0.006*      |         |
| HDL (mg/dL)           | 1.046 (1.025-1.066) | <0.001*     |         |
| LDL (mg/dL)           | 1.024 (1.019-1.030) | <0.001*     |         |
| Uric acid (mg/dL)     | 2.043 (1.768-2.361) | <0.001*     |         |
| Creatinine (mg/dL)    | 0.074 (0.038-0.145) | <0.001*     |         |
| ESR (mm/1st h)        | 0.965 (0.951-0.979) | <0.001*     |         |
| CRP (mg/L)            | 0.973 (0.963-0.984) | 0.004*      |         |
| 25-hydroxyvitamin D   | 1.057 (1.038-1.077) | <0.001*     |         |
| AST (IU/L)            | 0.983 (0.973-0.992) | <0.001*     |         |
| Real-time PCR Ct values | 0.961 (0.932-0.991) | 0.011*      |         |
| TMPRSS2 rs12329760 (CC) | 16.723 (10.841-25.798) | <0.001*     |         |

HDL: high-density lipoprotein; LDL: low-density lipoprotein; ESR: erythrocyte sedimentation rate; CRP: C-reactive protein; AST: aspartate aminotransferase; Ct: cycle threshold; TMPRSS2: transmembrane protease 2; SD: standard deviation; OR: odds ratios; CI: confidence intervals; * Statistically significant (<0.05).

COVID-19 [31]. According to a previous study, this polymorphism might have contributed to the spread of COVID-19 among the Italian population, which had a high mortality rate and poor prognosis [18]. Moreover, it was demonstrated that TMPRSS2 rs12329760 had a predictive value for identifying individuals at risk of developing severe COVID-19 [20]. In contrast, Wulandari et al. discovered no correlation between the TMPRSS2 rs12329760 CC genotype and COVID-19 mortality [32]. The limitations of this study were lack of examination of other effective polymorphisms in TMPRSS2 gene, and the effects of this SNP on TMPRSS2 expression were not studied.

In conclusion, the C allele of the common TMPRSS2 rs12329760 polymorphism confers an increased risk of COVID-19 mortality rate. Furthermore, clinical parameters, including AST, LDL, HDL, uric acid, 25-hydroxyvitamin D, and real-time PCR Ct values, were linked to the severity of infection. However, the findings of the present study might develop new ideas about how to use TMPRSS2 rs12329760 SNP as a predictor or biomarker of COVID-19 severity or clinical results.

Data Availability

The data used to support the findings of this study are included within the article and supplementary file.

Disclosure

This study was performed at Pasteur Institute of Iran.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors’ Contributions

Saeedeh Sadat Beheshti Shirazi and Fatemeh Sakhaee contributed equally to this work.

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Supplementary Materials

Supplementary Figure 1: the result of TMPRSS2 rs12329760 genotyping with T-ARMS-PCR Ladder 100 bp. Lane No. 1 is genotype TT (701 bp and 487 bp), Lane No. 5 is genotype CT.
(701 bp, 487 bp, and 275 bp), and Lane No. 8 is genotype CC (701 bp and 275 bp). Supplementary Figure 2: the sequencing results of TMPRSS2 rs12329760 genotypes for confirming the T-ARMS-PCR method (10% of samples randomly were sequenced). (Supplementary Materials) (Supplementary Materials)

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