The Benefits of UVB Exposure to Covid-19: A Literature Review Study

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ABSTRACT
COVID-19 is a disease caused by SARS CoV-2, which has infected almost all countries globally and designated by WHO as a pandemic until now. COVID-19 has caused multiple mortalities and affected many material and non-material losses. Many public authorities and researchers have contributed to dealing with this pandemic. The theory application regarding the benefits of exposure to UVB rays in COVID-19 is essential to study further. This literature review assessed the benefits of exposure to UVB rays in COVID-19. This research was a literature review. The keywords used were ("Ultraviolet-B" OR UVB) AND ("COVID-19" OR "SARS-coV-2" OR "2019-nCoV disease" OR "Coronavirus disease-19" OR "2019 novel coronavirus disease"). The databases used were Google Scholar, PubMed, and Science Direct. The inclusion test eligibility criteria included articles in English, articles having a direct or indirect relationship between exposure to UVB rays and COVID-19, all countries, all ethnicities and races, and articles from 2019 to 2021. The exclusion criteria were e-books and journals with pre-proof, pre-print, article in press, and systematic review status. Journals that were relevant to the topic were synthesized using narrative analysis techniques. A search with the related keywords resulted in 999 articles from Google Scholar, 33 articles from PubMed, and 189 articles from Science Direct. In general, the results showed that the benefits of exposure to UVB rays in COVID-19 are UVB synthesis of vitamin D into 25-OH vitamin D3, which functions as an immunomodulator, anti-inflammatory, anti-fibrotic, lowers CFR COVID-19 and cumulative mortality of COVID-19 19, enhances immunity to viral and bacterial infections, inactivates the SARS CoV-2 virus, reduces airborne virus transmission, and increases venous oxygen.

Keywords*: COVID-19, UVB*

1. INTRODUCTION

COVID-19 was first reported in Wuhan, China, on December 29, 2019, with five confirmed positive cases. The World Health Organization (WHO) declared this case a pandemic on March 11, 2020, until now. The spread of the first case of COVID-19 in Indonesia was on March 2, 2020, with two people who were confirmed positive for COVID-19 from Jakarta, and the cases continued to grow and were followed by a high mortality rate to date [1,2]. COVID-19 is caused by a coronavirus, which is a positive single-strain RNA virus, round or oval, encapsulated, and not segmented with the S protein on the viral surface. Spike protein is a viral antigen and structure that functions for the attachment and entry of the virus into host cells and then binds to the ACE-2 receptor [3,4]

Exposure to sunlight contains various types of ultraviolet, which can be classified into UVA in the range of 320 - 400 nm, UVB in the range of 290 - 315 nm, and UVC in the range of 200 - 290 nm. UVB is ultraviolet, beneficial, and safe for humans [5]. Vitamin D synthesis from UVB requires sun exposure on the face, arms, back, or legs for at least 15-30 minutes from 10.00 to 15.00 at least three days/week [5,6]. Vitamin D from the synthesis of UVB exposure lasts twice as long in the blood than consumed through food or supplements [6].

UVB has several benefits during the COVID-19 pandemic, including playing a role in synthesizing vitamin D in the skin (stratum basal and stratum spinosum) through thermal reactions and inactivation of SARS CoV-2. The result of the metabolism and regulation of vitamin D from exposure to UVB rays in its active form is 25-OH vitamin D3 that acts as an immunomodulator with natural and adaptive immune system mechanisms, reduces the risk of infection and the rate of viral replication, and diminishes pro-inflammatory cytokines [7].

Application theory regarding the benefits of UVB exposure to COVID-19 is crucial to study further. Hence, this literature review study aims to determine the benefits of exposure to UVB rays against COVID-19.

2. METHOD

This research is a literature review using research samples obtained from several databases, including Google Scholar, PubMed, and Science Direct. The keywords used were (“Ultraviolet-B” OR UVB) AND (“COVID-19” OR “SARS-CoV-2” OR “2019-nCoV Disease” OR “Coronavirus Disease-19” OR “2019 Novel Coronavirus Disease”).

The inclusion test eligibility criteria included articles in English, articles having a relationship between UVB exposure to COVID-19, all countries, all ethnicities, and races, and articles for 2019-2021. The exclusion criteria were e-books and journals with pre-proof, pre-print, article in-press, and systematic review status. PRISMA flowchart diagram was utilized as a journal identification technique. Journals that have relevance to the topic were analyzed narratively.

3. RESULTS

3.1. Article Search Results

The stage of searching for articles in several databases resulted in 189 articles from Science Direct, 999 articles from Google Scholar, and 33 articles from PubMed. After deducting the results of duplication, the number of articles was 1127. Then, 502 irrelevant title articles were excluded. The full-text screening was 625 articles. Lastly, 613 articles were eliminated with the exclusion eligibility criteria. Thus, there were twelve articles included in the inclusion eligibility criteria, which were then analyzed using narrative techniques. The search results for the PRISMA flowchart diagram are shown in Figure 1 below.

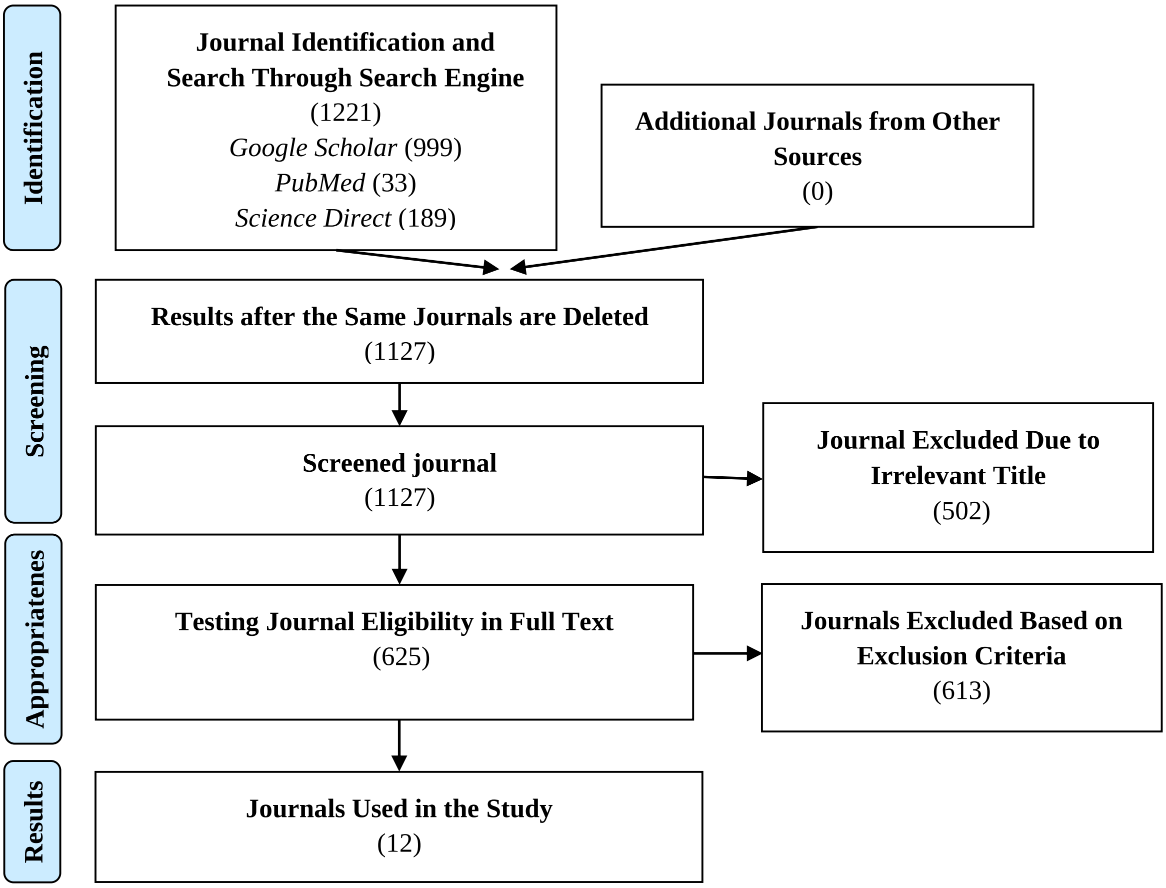

Figure 1 Search results with the PRISMA flowchart diagram

3.2. Study Characteristics

Table 1 shows the characteristics of the study that the research includes seven experimental studies, one case report, one brief report, two review articles, and one review. Two studies were conducted in India, one in Croatia, two in Italy, one in the United States, one in Pakistan, one in Canada, one in Spain, one in Egypt, one in China, and one in Saudi Arabia. Two studies were conducted in 2020, and ten studies were conducted in 2021.

Table 1. Study Characteristics

No	Author and Year	Journal	Location	Design
1	Rahul Kalippurayil et al (2020)	Scientific Reports	India	*Experimental*
2	Rahul Kalippurayil et al (2021)	Scientific Reports	India	*Experimental*
3	Martina et al (2021)	Authorea	Croatia	*Case report*
4	Fabrizio Nicastro et al (2021)	Scientific Reports	Italy	*Experimental*
5	Mar Guasp et al (2021)	Clinical Infectious Diseases	Spain	*Brief report*
6	Wisam Kadhum et al (2021)	Egyptian Journal of Chemistry	Egypt	*Experimental*
7	Shanna Ratnesar et al (2020)	The Journal of infectious diseases	The United States of America	*Experimental*
8	Angela Sloan et al (2021)	Plos Satu	Canada	*Experimental*

9	Hasham Hussain et al (2021)	Canadian Journal of Medicine	Pakistan	*Article Review*
10	Alberto Borreti et al (2021)	Clinical Reviews in Allergy & Immunology	Saudi Arabia	*Article Review*
11	Nicola Trivellin et al (2021)	Electronics	Italy	*Review*
12	Xue Li et al (2021)	Scientific Reports	China	*Experimental*

3.3. Subject Characteristics

Table 2 shows that the characteristics of the research subjects are countries with positive cases of COVID-19, including hospitalization, mortality cases, co-morbidities with hypertension, DM, psoriatic arthritis, UVB exposure, the culture of SARS-CoV-2, a solar simulator with UVB range, and SARS CoV-2 aliquots.

Table 2. Subject Characteristics

No	Author and Year	Number of Subjects	Subject Characteristics
1	Rahul Kalippurayil et al (2020)	Six thousand five hundred twenty-four patients with COVID-19 mortality and CFR	1. Six thousand five hundred twenty-four patients from 183 countries, of which 158 countries reported the number of mortalities from COVID-19 and 152 countries reported more than 20 countries with COVID-19 infections. The study focused on people in 152 countries to ensure that the results were not biased over 108 days.
2	Rahul Kalippurayil et al (2021)	Seven thousand seven hundred twenty-eight patients with COVID-19 infection	1. Seven thousand seven hundred twenty-eight people from 28 states and eight union territories in India with cases of COVID-19 infection during the 251-day rainy season. 2. Persons in 35 administrative regions reported more than 20 areas of COVID-19 infection. The research focused on 35 administrative regions to ensure unbiased results.
3	Martina et al (2021)	One person	1. A 66-year-old Caucasian man was diagnosed with hypertension eight years ago and type 2 diabetes mellitus six years ago. Hypertension was treated with hydrochlorothiazide (50 mg/day), and type 2 diabetes was treated with metformin (500 mg, three times/day). 2. He was also diagnosed with psoriatic arthritis six years ago and was treated with methotrexate 15 mg/week subcutaneously and to prevent folate deficiency, he was receiving folic acid 5 mg 2 times/week. Three months before experiencing an exacerbation of psoriatic arthritis, he received UVB phototherapy for two months. 3. He also confirmed positive for COVID-19 and described mild symptoms of COVID-19.
4	Fabrizio Nicastro et al (2021)	An online GitHub data repository by Johns Hopkins University with data for 214 locations recording COVID-19 mortality rates	1. UV spectrum with a range of 254 nm, 278 nm, 308 nm, 366 nm, and 405 nm. 2. The virus concentration of 6×106 TCID with TCID50 replication virus was performed for four months. 3. It was conducted in two regions and three seasons (Summer, Spring, and Autumn)

5	Mar Guasp et al (2021)	Cumulative case of COVID-19 per 100,000 population during the study period.	1. COVID-19 data by Johns Hopkins for total mortality of 359 countries and territories in the countries with the highest number of cases and two additional repositories calculated 2. Maximum UV index (0-11+) and global average solar radiation (W/m^2) for 30 days.
6	Wisam Kadhum et al (2021)	SARS-CoV-2 virus in aqueous media	1. UVB254-D90 44.9 J/m^2 with a range between 3-120 J/m^2, a mean value of 51.9 J/m^2, a mean standard deviation of 14.2 J/m^2 and a 95% confidence interval ranging from 19, 8 to 84.0 J/m^2 over four months conducted in one state and two seasons (Summer and Winter).
7	Shanna Ratnesar et al (2020)	SARS-CoV-2 sourced BEI (NR-52281) in vero cells	1. Chamber with quartz window using a spectroradiometer model spectrum (OL756; Gooch & Housego) in the UVA and UVB ranges of TUV NCAR radiation.
8	Angela Sloan et al (2021)	SARS-CoV-2 in virus aliquots	1. UVB was measured with a SunLite Solar Simulator model 11002 at 41.46 W/m^2.
9	Hasham Hussain et al (2021)	-	It did not require subject characteristics because it was a review article.
10	Alberto Borreti et al (2021)	-	It did not require subject characteristics because it was a review article.
11	Nicola Trivellin et al (2021)	-	It did not require subject characteristics because it was a review article.
12	Xue Li et al (2021)	Fourteen thousand four hundred thirty-nine persons	1. Fourteen thousand four hundred thirty-nine participants from 495,780 UK Biobank, 1,596 were confirmed positive for COVID-19, 1,020 were hospitalized, and 399 were identified from a 103-day COVID-19 mortality register.

3.4. Study Results

Table 3 shows that the study results of the benefits of UVB exposure to COVID-19 are synthesizing vitamin D into 25-OH vitamin D3, which functions as an immunomodulator, anti-inflammatory, anti-fibrotic, antioxidant, anti-viral, decreases CFR COVID-19, diminishes in cumulative COVID-19 mortalities, reduces COVID-19 mortality, produces anti-inflammatory cytokines, reduces pro-inflammatory cytokines, builds antibodies in the human body for SARS CoV-2, inactivates SARS CoV-2, lowers virus transmission through airborne transmission, stability of the SARS CoV-2 virus variant, enhances venous oxygen, and increases resistance to viral and bacterial infections.

Table 3. Study Reults

No	Author and Year	Study Results
1	Rahul Kalippurayil et al (2020)	1. UVB had a protective role mediated by vitamin D synthesis to reduce mortality cases from COVID-19. 2. UVB radiation decreased the cumulative daily growth rate of COVID-19 mortalities by 1.2% (-12%) with < 0.01 and reduced daily growth rate of 1.0% (-38%) CFR with < 0. 05.
2	Rahul Kalippurayil et al (2021)	1. UVB played a role in the synthesis of vitamin D in the skin.

		2. UVB reduced the daily growth rate of COVID-19 mortalities by 0.92% with <0.01. 3. The monsoon season reduced the protective role of the UV index (UVI) by 77%.
3	Martina et al (2021)	1. UVB phototherapy made 25-OH vitamin D3 levels in the human body sufficient. 2. 25-OH vitamin D3 functioned as an immunomodulator, anti-inflammatory, promoted T helper 2 response, produced anti-inflammatory cytokines (IL-4, IL-10), induced the production of IFN-1 for anti-viral activity in humans, viral clearance, and control virus replication. 3. UVB phototherapy increased the levels of T reg and naive B cells.
4	Fabrizio Nicastro et al (2021)	1. UVB in the 308 nm range was the lethal dose for SARS CoV-2. 2. UVB inactivated SARS CoV-2 in aerosols and surfaces. 3. UVB exposure could inactivate the SARS CoV-2 virus during the day with a time of 1.5 to 3 minutes. 4. UVB modulated the diffusion of the COVID-19 pandemic.
5	Mar Guasp et al (2021)	1. UVB had a potent anti-viral effect, so it is effective for the inactivation of SARS CoV-2. 2. UVB modulated immunity against viral infections by activating innate and adaptive immune responses. 3. UVB controlled the production of vitamin D in the human body.
6	Wisam Kadhum et al (2021)	1. In summer, it required UVB exposure with a span of 3 to 9 minutes to inactivate SARS CoV-2. 2. The geographic location of Baghdad represented the sensitivity of UVB254 D90 for coronavirus in bio-defense ranging from 3 to 129 J/m² and within 95% CI confidence intervals.
7	Shanna Ratnesar et al (2020)	1. The rate of inactivation of the SARS CoV-2 virus on exposure to UVB irradiation was significantly faster than without UVB with <0001. 2. The inactivation rates for UVB radiation were 0.7 W/m² and 1.6 W/m² 3. UVB irradiation of 0.3 W/m², 0.7, W/m², 1.6 W/m² would eliminate viral infections by 90% every 12.8 minutes, 8.0 minutes, and 6.8 minutes. 4. The level of UVB by natural sunlight quickly inactivated SARS CoV-2, especially for viruses that were dried on stainless steel coupons and surfaces.
8	Angela Sloan et al (2021)	1. UVB exposure significantly decreased the survival of SARS CoV-2 compared to conditions when sunlight was removed. 2. UVB inactivated SARS CoV-2 in 1.28 W/m² dried on a stainless-steel surface. 3. UVB inactivated 90% of SARS CoV-2 virus strains in 6.8 minutes.
9	Hasham Hussain et al (2021)	1. UVB could inactivate airborne coronaviruses, reduce airborne transmission, and stabilize viral variants. 2. In warmer climates, the rate of COVID-19 cases was increasing, but the virulence was reduced. Thus, the mortality rate was much lower than the infection rate. 3. During the summer, the transmission of the SARS-CoV-2 virus decreased.
10	Alberto Borreti et al (2021)	1. UVB increased venous oxygen, enhances viral and bacterial infection resistance, rapidly detoxified the virus, anti-inflammatory effect, and regulatory effect. 2. UVB formed antibodies in humans for SARS CoV-2. 3. UVB increased monocytes, decreased CD14+ and inhibited HLA-DR and ICAM-1 regulatory processes, immunosuppression of T lymphocytes, and increased phagocytic activity. 4. Low doses of UVB (LD50 05-1 mJ/cm²) could kill T-cells in 48 to 72 hours.
11	Nicola Trivellin et al (2021)	1. UVB inactivated SARS CoV-2. 2. The UV range for the highest anti-viral effect was 260 nm.

		3. UV with a range of 280 nm was the highest anti-viral effect, with a dose two to three times higher than the range of 260 nm. 4. UV in the range of 275-285 nm was the most effective range for the inactivation of SARS CoV-2.
12	Xue Li et al (2021)	1. VitD-UVB was not associated with COVID-19 infection but was strongly associated with hospitalizations and mortalities. 2. VitD-UVB decreased positive cases, reduced severity and mortality of COVID-19 (OR = 0.98, 95%CI = 0.97-0.99) 3. VitD-UVB levels were 50% lower in people who died from COVID-19 than those who did not require hospitalization. 4. VitD-UVB recruited the most significant portion of 25-OH vitamin D3

4. DISCUSSION

From the results of the literature review presented in the table of subject characteristics, based on the characteristics of UVB exposure, it shows that five journals use natural UVB rays that come from exposure to sunlight that is separated by wavelength [8,9,10,11,12]. Meanwhile, four journals used artificial UVB rays with the chamber using a spectroradiometer spectrum model and SunLite solar simulator [13,14,15,16]. The other three journals were journal reviews. The characteristic results based on COVID-19 show six journals revealing that by using participants with positive confirmed cases of COVID-19, mortality, CFR, and the cumulative case of COVID-19 [8,9,10,11,12,13]. Meanwhile, three journals used SARS-CoV-2 culture in aqueous media and vero and aliquot virus-cell media [14,15,16]. The other three journals were journal reviews.

The results of the literature review presented in the table of research results show that from the four journals analyzed, the benefits of exposure to UVB rays in COVID-19 were the synthesis of vitamin D in the skin into 25-hydroxyvitamin D3 [8,9,11,12]. Another result of one analyzed journal showed the benefit of UVB exposure in COVID-19, namely to increase 25-hydroxyvitamin D3 levels in the body [13]. The benefits of 25-hydroxyvitamin D3 were immunomodulatory, anti-inflammatory, anti-viral, anti-fibrotic, antioxidant. Immunomodulators play a role by producing anti-inflammatory cytokines, reducing pro-inflammatory cytokines, forming antibodies in the body for SARS CoV-2, thereby reducing CFR COVID-19, cumulative COVID-19 deaths, and COVID-19 severity [8,9, 11,12,13,17].

Immunomodulator undergoes the natural and adaptive immune system. The natural immune system's mechanism is activating anti-viral peptides to kill viruses (cathelicidin LL-37, -defensin, TLR expression) from 25-hydroxyvitamin D3, activating macrophages, monocytes, and dendritic cells for phagocytosis and increasing the function of NK cells to kill the virus. In addition, the natural immune system also activates anti-infective defenses by increasing the release of nitric oxide (NO) and increasing the production of lysosomal enzymes [18,19].

The humoral and cellular immune systems mediate the mechanism of the adaptive immune system. Cellular immune system, by reducing levels of NFkB, decreases the expression of pro-inflammatory cytokines (IL-10, TNF-α, IFN-γ, IL-12, IL-1, IL-2) by inhibiting Th1, which is a pro-inflammatory, thereby increasing the expression of anti-inflammatory cytokines produced by macrophages, inducing Th2 cells & T reg cells and suppressing Th1 cells by helping to increase the production of anti-inflammatory cytokines to prevent the severe inflammatory process in patients with severe COVID-19 and increase the expression of antioxidant genes (glutathione reductase and subunit glutamate-cysteine ligase modifier) to overcome oxidative stress in fighting free radicals, preventing cell damage and saving the use of ascorbic acid, which has anti-viral activity. The mechanism of the humoral immune system is to reduce T cell proliferation, decrease dendritic cell maturation and presentation of APC cells in presenting the SARS CoV-2 antigen, replace Th1 cells with Th2 shift cells and Th17 cells with T reg cells, lower IgM & IgG production in patients with Mild COVID-19 where IgM & IgG levels will increase on day 7-10, and decrease B cell proliferation to prevent tissue damage, reduce the risk of severity and death in COVID-19 sufferers [17,18,20].

In addition, UVB can suppress delayed-type hypersensitivity reactions to viruses, increase blood flow and infiltration of macrophages and neutrophils and also reduce the production of lipid peroxidation, which will reduce the production of prostaglandins to reduce the occurrence of inflammation both mild and severe in patients with COVID-19 [21].

The results of the literature review research presented in the table of research results show that there are seven journals from a public health perspective. From four journals, it was shown that the benefits of UVB exposure to COVID-19 were for the inactivation of SARS CoV-2 in aerosols and stainless and non-stainless surfaces in 1.5-12 minutes [10,14,15,16]. One journal showed decreased SARS CoV-2 survival significantly [16]. One journal showed reduced airborne transmission and stability of the virus in a warmer climate so that its virulence levels were reduced. It results in a much lower mortality rate than the infection rate [22]. One journal showed increased venous oxygen, increased resistance to viral and bacterial infections, and rapid viral detoxification and regulatory effects [17]. Two journals showed that the wavelength for the effective lethal dose for anti-viral effect was in the range of 275-308 nm [10,23].

The results of this literature review study can provide an overview of the benefits of exposure to UVB radiation in COVID-19 for practical purposes in the field, clinical or for research.

5. CONCLUSION

The benefit of exposure to UVB rays on COVID-19 is to synthesize vitamin D into 25-OH vitamin D3, which functions as an immunomodulator, anti-inflammatory, anti-fibrotic, and antioxidant. Immunomodulators work with the mechanisms of the natural immune system and the adaptive immune system. These mechanisms play a role in reducing the CFR of COVID-19, reducing cumulative COVID-19 mortalities, decreasing COVID-19 mortality rate, producing anti-inflammatory cytokines, reducing pro-inflammatory cytokines, building antibodies in the body for SARS CoV-2, producing ROS, increasing venous oxygen, increasing immunity against viral and bacterial infections.

In addition, the benefits of exposure to UVB rays on COVID-19 are to inactivate the SARS CoV-2 virus by rapidly detoxifying the virus and reducing the survival of the SARS CoV-2 virus. Inactivation of SARS CoV-2 plays a role in reducing the transmission of the SARS CoV-2 virus through the air and stabilizing the SARS CoV-2 virus variant, especially in warmer climates, so that its virulence is reduced. It would lead to a much lower-case fatality rate than the infection rate.

AUTHOR'S CONTRIBUTIONS

ASF contributed to article writing, data collection, data processing, and article preparation. BI participated in writing the article, reviewing articles carefully, providing guidance, input, and suggestions.

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