Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Heightened religiosity proactively and reactively responds to the COVID-19 pandemic across the globe: Novel insights from the parasite-stress theory of sociality and the behavioral immune system theory

Mac Zewei Ma * ,1

Department of Social and Behavioural Sciences, City University of Hong Kong, Hong Kong

ARTICLE INFO

Keywords:
COVID-19
Parasite-stress theory of sociality
Behavioral immune system theory
Religiosity
Big data
Multilevel analysis

ABSTRACT

According to the parasite-stress theory of sociality and the behavioral immune system theory, heightened religiosity serves an anti-pathogen function by promoting in-group assortative sociability. Thus, highly religious countries/territories could have better control of the COVID-19 (proactively avoids disease-threat), and heightened COVID-19 threat could increase religiosity (reactively responds to disease-threat). As expected, country-level religiosity (religion-related online searches (Allah, Buddhism, Jesus, etc.) and number of total religions/ethnoreligions) negatively and significantly predicted COVID-19 severity (a composite index of COVID-19 susceptibility, reproductive rate, morbidity, and mortality rates) (Study 1a), after accounting for covariates (e.g., socioeconomic factors, ecological factors, collectivism index, cultural tightness-looseness index, COVID-19 policy response, test-to-case ratio). Moreover, multilevel analysis accounting for daily- (e.g., time-trend effect, season) and macro-level (same as in Study 1a) covariates showed that country-level religious searches, compared with the number of total religions/ethnoreligions, were more robust in negatively and significantly predicting daily-level COVID-19 severity during early pandemic stages (Study 1b). At weekly level, perceived coronavirus threat measured with coronavirus-related searches (corona, covid, covid-19, etc.), compared with actual COVID-19 threat measured with epidemiological data, showed larger effects in positively predicting religious searches (Study 2), after accounting for weekly- (e.g., autocorrelation, time-trend effect, season, religious holidays, major-illness-related searches) and macro-level (e.g., Christian-majority country/territory and all country-level variables in Study 1) covariates. Accordingly, heightened religiosity could proactively and reactively respond to the COVID-19 pandemic across the globe.

Introduction

Humans are immunologically adaptive to local pathogens due to localized host-parasite coevolutionary races (Fincher & Thornhill, 2012). Thus, allying with immunologically similar in-group members could avoid and manage novel parasites harbored by out-group

* Correspondence to: Department of Social and Behavioural Sciences, City University of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong. E-mail address: mac.ma@cityu.edu.hk.
1 https://orcid.org/0000-0003-2073-8339.

https://doi.org/10.1016/j.ijintrel.2022.07.005
Received 25 November 2021; Received in revised form 5 July 2022; Accepted 10 July 2022
Available online 13 July 2022
0147-1767/© 2022 Elsevier Ltd. All rights reserved.
people (Fincher & Thornhill, 2008, 2012; Thornhill & Fincher, 2014a, 2014b). The parasite-stress theory of sociality proposes that in-group assortative sociality (Thornhill & Fincher, 2014c), which is “preferential association among similar individuals who compose an in-group versus out-group or dissimilar others” (Fincher & Thornhill, 2012), is valued in areas of high parasite-stress (Thornhill & Fincher, 2014a). Empirical research supports the parasite-stress theory of sociality by showing that people in ecological settings of high pathogen risks are inclined to show strong in-group favoritism and out-group dislike (Fincher & Thornhill, 2012; Fincher et al., 2008; Murray & Schaller, 2010; O’Shea et al., 2022; Santos et al., 2017; Thornhill & Fincher, 2014a; Thornhill et al., 2010; Tybur et al., 2016; Zmigrod et al., 2021). As an anti-pathogen strategy (Fincher & Thornhill, 2012; Fincher et al., 2008), in-group assortative sociality is related to the behavioral immune system (BIS) (Thornhill & Fincher, 2014b), which is a set of cognitive, affective, and behavioral mechanisms for reducing disease threat (Schaller, 2011). According to the BIS, people will reactively and proactively respond to pathogen threat (Ackerman et al., 2018; Schaller et al., 2015).

On the one hand, BIS reactive responses are activated when pathogen cues are made salient (Calpepper et al., 2018; Karwowski et al., 2020; Schaller et al., 2015; Tybur et al., 2011; Wu et al., 2015). As exposing to pathogen cues (e.g., dirty objects) increased in-group bias (Faulkner et al., 2004; Navarrete & Fessler, 2006; Wu & Chang, 2012), valuing strong in-group assortative sociality could be a BIS reactive response (Ma, 2022; Ma & Ye, 2021b). On the other hand, some BIS responses are more proactive (Schaller et al., 2015). That is, people will engage in behaviors which can proactively avoid pathogen risk in the long run (e.g., hand washing before meal) under conditions in which no immediate pathogen threat is detected (Ackerman et al., 2018; Schaller et al., 2021; Stevenson et al., 2011). As infectious diseases have imposed selection pressure on human ancestors (Schaller et al., 2015), many cultural norms serve to proactively defend people against pathogen threat (Murray & Schaller, 2012; Schaller et al., 2015, 2021; Stevenson et al., 2011). Given that features of in-group assortative sociality (e.g., xenophobia) are adaptive anti-pathogen strategies developed under localized host-parasite coevolutionary races (Fincher & Thornhill, 2012), strong in-group assortative sociality functions as a social defensive mechanism for reducing transmissible risks of novel infectious diseases in the long run (Morand & Walther, 2018). Thus, heightened in-group assortative sociality could be a BIS proactive response (Ma, 2022; Ma & Ye, 2021b).

Recent social and cross-cultural psychological studies on Coronavirus disease 2019 (COVID-19) show that features of in-group assortative sociality (e.g., xenophobia) were responsive to the COVID-19 pandemic (Chan & Saqib, 2021; Karwowski et al., 2020; Moran et al., 2021; Sorokowski et al., 2020). Meanwhile, regions valuing strong in-group assortative sociality (e.g., collectivism) had better control of the novel coronavirus (Canatay et al., 2021; Gokmen et al., 2021; Liu, 2021; Maaravi et al., 2021; Rajkumar, 2021). Thus, in-group assortative sociality could reactively and proactively respond to the COVID-19 pandemic (Ma, 2022; Ma & Ye, 2021b). Indeed, Ma and Ye (2021b) have tested the parasite-stress theory of sociality from the BIS perspective and showed that strong family ties and heightened religiosity, two extended elements of in-group assortative sociality (Fincher & Thornhill, 2012), significantly and negatively predicted COVID-19 severity across American states. Using Google Trends, a big data tool which is frequently employed to track the public interests on specific topics during the pandemic (Adam-Troian & Bagci, 2021; Ma, 2022; Ma & Ye, 2021a, 2021b), Ma and Ye (2021b) found that increases in collective concerns regarding the threat of COVID-19 predicted increases in American people’s interests in searching for information related to family ties and religions. Importantly, heightened religiosity, compared with strong family ties, was more strongly related to the COVID-19 pandemic (Ma & Ye, 2021b). This finding suggests that religions have their own unique functions during the deadly pandemic.

According to Fincher and Thornhill (2012), participation in a religion is costly, such as opportunity loss (e.g., disengaging in other fitness-enhancing activities) and large amounts of time and energy invested in learning religious law and practicing it. As the costs of religious participation screen out members who are religiously uncommitted (Iannaccone, 1994) and the strictness of religious practice makes it too costly to desert to other religions (Fincher & Thornhill, 2012), heightened religiosity, which is an honest signal of “embeddedness in and commitment to an in-group with a particular spiritual belief system” (Fincher & Thornhill, 2012), denotes strong in-group commitment and loyalty. Moreover, as religious in-groups are adaptive to the religiously prescribed norms (e.g., hygiene-related rules) (Allegranzi et al., 2009; Jaglarz, 2013), alliance to the religious in-groups builds an immunological barrier to avoid novel parasites harbored by out-group individuals (Fincher & Thornhill, 2012). As religion also promotes in-group pro-sociality (Preston & Ritter, 2013; Purzycki & Kulundary, 2018; Willard et al., 2020), maintaining religious alliance could mitigate disease risks within religious members (Fincher & Thornhill, 2012).

Religion is a drive of moral judgments (Hone et al., 2020; Kirchmaier et al., 2018; Minton et al., 2019; Willard et al., 2020), and heightened religiosity promoted group-focused moral foundations (LaBouff et al., 2017; Minton et al., 2019). As prioritizing the group-focused moral foundations of ingroup/loyalty, authority/respect, and purity/sanctity reflects a reactive BIS (Makanova et al., 2019; Van Leeuwen et al., 2017, 2012), the morality perspective highlights the anti-pathogen function of heightened religiosity (Fincher & Thornhill, 2008, 2012; Ma & Ye, 2021b). While the ingroup/loyalty and authority/respect moral foundations provide insights into the in-group bias of heightened religiosity (Fincher & Thornhill, 2012), the purity/sanctity moral foundation serves as a core basis for the anti-pathogen function of heightened religiosity (Fincher & Thornhill, 2008, 2012; Ma & Ye, 2021b). The moral foundation of purity/sanctity underlies the psychology of the “desire to keep the body and mind ‘clean’ or ‘pure’” (LaBouff et al., 2017). Thus, purity/sanctity regulates people’s biological disgust (Horberg et al., 2009) and contamination concerns regarding bodily cleanliness (Preston & Ritter, 2012). It suggests that purity/sanctity serves to reduce pathogen risk (Haidt & Joseph, 2007). In this regard, religious doctrines across cultures unsurprisingly include various strict hygiene-related rules (Allegranzi et al., 2009; Jaglarz, 2013).

Although religious gatherings such as religious pilgrimages, funerals, and traveling to shrines increased the transmissible risk of COVID-19 during early pandemic stages (Lee et al., 2021), religious norms about healthy behaviors (e.g., physical purity and cleanliness) and religious prohibitions on unhealthy lifestyles (e.g., drug abuse) highlight the practical significance of religion for mitigating the devastating effect of COVID-19 (Barmania & Reiss, 2021). For example, religious hygiene practices, such as bodily
cleanliness (Allegranzi et al., 2009; Jaglacz, 2013), reduced the transmission of COVID-19 (Przekwas & Chen, 2020). More importantly, heightened religiosity promotes strong moral concerns (Hone et al., 2020; Kirchmair et al., 2018; LaBouff et al., 2017; Minton et al., 2019; Willard et al., 2020) for pathogen avoidance (Makhanova et al., 2019; Van Leeuwen et al., 2017, 2012). Thus, the findings that stronger moral concerns contributed to greater behavioral compliance with lockdown measures (Lo Presti et al., 2022) and COVID-19 prevention and discretionary behaviors (Pagliaro et al., 2021) support the role of heightened religiosity in mitigating the devastating effect of COVID-19.

On the one hand, as each pathogen, irrespective of its prevalence, shapes in-group assortative sociality (Fincher & Thornhill, 2012; Thornhill & Fincher, 2014a), pathogen richness strongly and positively predicted religion diversity (Fincher et al., 2008). Considering that religious practices (rituals, festivals, prayer, etc.) vary across religions, religion diversity could capture the degree to which people use religions (i.e., religiously extrinsic practices) (Allport & Ross, 1967) for pathogen avoidance (Fincher & Thornhill, 2008). Moreover, because individuals high on intrinsic religiosity integrate religions into their lives (Cohen et al., 2017), searching for religious information on the Internet could capture the internalization of religious beliefs across millions of people (Alper, 2019; Pelham et al., 2018) to assess the degree to which people live their religions (i.e., internalized and inner motivated religiosity) (Allport & Ross, 1967) for pathogen avoidance (Ma & Ye, 2021b). Therefore, if heightened religiosity does indeed serve an anti-pathogen function (Fincher & Thornhill, 2008, 2012), countries/territories with more religions/ethnoreligions and more religious searches, compared with less religious countries/territories, could have better control of the COVID-19 outbreak. On the other hand, recent development of Internet technologies and ease of retrieving online query data enable social and cross-cultural psychologists to test the effects of COVID-19 pandemic on influencing human psychology across different populations (Brodeur et al., 2021; Husain et al., 2020; Husnayain et al., 2020; Ma, 2021b, 2022; Ma & Ye, 2021a, 2021b, 2022). If indeed heightened religiosity is for pathogen avoidance (Fincher & Thornhill, 2008, 2012), religious searches would be responsive to heightened COVID-19 threat, given that intrinsic religiosity assesses the extent to which people are intrinsically motivated to be religious (Allport & Ross, 1967; Cohen et al., 2017).

Overall, the present research attempts to extend the American findings in Ma and Ye (2021b) at worldwide level by testing that religiosity would negatively predict COVID-19 severity across countries/territories (Study 1), and heightened COVID-19 threat (perceived vs. actual) would positively predict changes in religiosity across different populations (Study 2). Thus, the present research expects to provide support for the proposal that heightened religiosity serves an anti-pathogen function (Fincher & Thornhill, 2008, 2012), which could proactively and reactively respond to the COVID-19 pandemic (Ma & Ye, 2021b).

Study 1a

Methods

Countries/territories in the current study

There were 191 countries/territories in this study, but the final sample size depended on the availability of data on all variables (e.g., sociocultural factors). The Online Supplemental Materials (OSM) presents the supplemental results. Table S1 summarizes the variables examined in this study (see OSM). The Open Science Framework (OSF) folder (https://osf.io/2ck6t/?view_only=dc792194e89644efb71792d8dd60e051) contains the data analyzed in this study.

Measures

COVID-19 severity index. Similar to Ma and Ye (2021b), a composite index of COVID-19 severity was calculated by sourcing data from Our World in Data (as accessed on July 23, 2021). First, COVID-19 susceptibility was estimated according to recent studies (Jankowiak et al., 2020; Ma & Ye, 2021b). Then, COVID-19 overall doubling time was calculated to measure the speed of COVID-19 propagation within the first 21 days since the first 25 cases (or over 25 cases) were documented (White & Hébert-Dufresne, 2020). Third, the daily average reproductive rate (between January 1, 2020 and July 21, 2021) was calculated to measure the average transmission speed of COVID-19. Fourth, the daily average case fatality rate (between January 1, 2020 and July 21, 2021) was calculated to measure the lethality of COVID-19 (Verity et al., 2020). This study also included COVID-19 cases per million (daily average) and COVID-19 deaths per million (daily average) to capture COVID-19 severity (Gelfand et al., 2021; Gokmen et al., 2021; Maaravi et al., 2021; Webster et al., 2021).

An exploratory factor analysis (EFA) with a direct oblimin rotation method extracted two components from the Z-transformed indicators. As overall doubling time had a low factor-loading while case fatality rate decreased the internal consistency of the remaining indicators, the final COVID-19 severity index was composed of susceptibility score, reproductive rate, morbidity rate, and mortality rate (factor loadings >.70), which explained a total of 75.15% of the variance in the unobserved construct. The COVID-19 severity index was created by averaging the Z-transformed indicators (Cronbach’s α =.64), with higher scores indicating greater levels of COVID-19 severity.

Religion diversity index. Fincher and Thornhill (2008) calculated the total number of religions/ethnoreligions per country/territory by sourcing data from Barrett et al. (2001). The current research transformed the index in Fincher and Thornhill (2008) to calculate the per capita religions/ethnoreligions (i.e., [number of total religions/2019 total population] × 100,000), which standardized the religion diversity index across countries/territories. Higher scores indicated greater levels of religious belongingness and more extrinsic practices.
Religious interest index estimated with Google Trends data. Internet query data are valuable sources for psychological researchers to gain insights into real-time psychological states across millions of people (Cheung et al., 2017) to examine the predictions of psychological theories outside laboratories (e.g., Adam-Troian & Arciszewski, 2020; Adam-Troian et al., 2021, 2022; Alper, 2019; Alper et al., 2020; Cheng et al., 2020; DiMuccio & Knowles, 2021; Ma & Ye, 2022; Pelham et al., 2018). Thus, this research used Google Trends, a big data tool tracking real-time online searches on specific topics (Arora et al., 2019), to capture people’s real-time intrinsic religiosity (Alper, 2019; Pelham et al., 2018). As detailed in recent studies, Google Trends data collection approaches (Ma, 2022; Ma & Ye, 2021a; Sousa-Pinto et al., 2020; Sousa-Pinto et al., 2021) were followed.

Keyword selection. As discussed in recent studies (Ma, 2022; Ma & Ye, 2021a, 2022; Sousa-Pinto et al., 2020, 2021), topic search terms were appropriate for cross-national comparative research, because such terms include the search volumes for all specific search terms that share similar concepts into the specific topics (Choi & Varian, 2012), irrespective of which languages are used to search these terms (Dilmaghani, 2020; Yeung, 2019). Therefore, using topic search terms can 1) capture similar concepts related to the religious search terms (e.g., Christ was related to Jesus), 2) rule out linguistic influences (e.g., different languages could be used to search for the religious terms), and 3) minimize the influences of noises (e.g., taboo words such as ‘Jesus Christ’; see Jay, 2009).

To determine the religion-related topic search terms, the CIA World Factbook (https://www.cia.gov/the-world-factbook/) was used to identify the major religions in the world, namely, Christianity, Islam, Buddhism, Hinduism, and Judaism. The current study used Prayer, Jesus, God, Allah, Prophet, Ayer, Hinduism, Vedas, and Atman as Christianity-, Islam-, and Hinduism-related topic search terms (Alper, 2019; Pelham et al., 2018). For Buddhism and Judaism, their core elements (figures, scriptures, laws, etc.) were identified from several sources (https://en.wikipedia.org/wiki/; https://www.history.com/; https://www.britannica.com/) to determine which religious keywords should be selected. Next, online dictionaries (https://www.oed.com/; https://www.dictionary.com/) were used to cross-validate that the selected keywords did indeed belong to and reflect the key elements of the targeted religions. Following this approach, Buddhism, Buddha, Bodhisattva, Zen, Torah, Tanakh, and Talmud were used as Buddhism- and Judaism-related topic search terms.

Region and period selection. The regional-level relative-search-volume (RSV) scores of the religious search terms were obtained for 191 countries/territories. Considering the causal time lag of religious searches on COVID-19 severity, the regional RSV scores were retrieved for the period between January 1, 2004 and January 1, 2020.

Search categories. No categories or subcategories were selected for the searches to filter the results to a certain category. Data were obtained from the web interface of Google Trends (https://trends.google.com/trends). The search terms were searched individually.

Google Trends religious interest index. Excluding the search terms Buddha and Bodhisattva enhanced the internal consistency of the remaining religious topic search terms (Cronbach’s α = .67), whose RSV scores were averaged for a religious interest index. According to one of the review comments, the per capita religious interest index was calculated for each country/territory (original index/2019 total population) × 100,000 to capture the degree to which people were desired to live their religions (Allport & Ross, 1967). The measurement validity of the current index was supported by its positive and significant correlation with religion diversity index, $r = .75$, $p < .001$.

Covariates

Latitude and disease richness. Latitude and disease richness were controlled to account for the effects of temperature and pathogen prevalence on the COVID-19 outbreak (Adedokun et al., 2020; Feng et al., 2022; Ma & Ye, 2021b). The per capita disease richness index was calculated from Fincher and Thornhill (2008).

Socio-political-economic-development index. A composite index was created to capture socio-political and economic development in each country/territory. First, as modernization indicators (e.g., GDP per capita, population density) predicted COVID-19 severity (e.g., Gangemi et al., 2020; Jankowiak et al., 2020; Roy & Ghosh, 2020), the modernization index in Ma (2021b) was used. Second, the democracy index (Economist Intelligence Unit; www.eiu.com), which assesses five defining components of democratization, was used to capture political development in each country/territory. Third, the KOF globalization index (https://kof.ethz.ch/en) (Dreher, 2006; Gygli et al., 2019), which captures globalization in the economic, social, and political dimensions, was used to gauge the level of globalization in each country/territory to rule out its effect on the COVID-19 pandemic (Bickley et al., 2021; Farzanegan et al., 2021). The international migrant stock, which is “the number of people born in a country other than that in which they live” (see World Bank; https://databank.worldbank.org/home.aspx), was used to supplement the KOF globalization index to measure global population mobility (Ananta & Ariffin, 2021). Fourth, the WHO universal health coverage index (UHC; https://www.who.int/data/monitoring-universal-health-coverage), which was tested in recent COVID-19 research (e.g., Lu et al., 2021), was used to assess the coverage of essential health services (Hogan et al., 2018) to capture the progression of improving equitable and sustainable population health outcomes (Dieleman et al., 2018). Fifth, the World Bank government effectiveness index (GEl; https://govdata360.worldbank.org/), a subjective measure of the government effectiveness across several domains (e.g., quality of public services) (Lee & Whitford, 2009), was used to capture the influence of government effectiveness on COVID-19 mortality (Feng et al., 2022).

Using an EFA with a direct oblimin rotation method, one component was extracted from the Z-transformed indicators, which explained 60.49% of the total variance in the unobserved construct. The Z-transformed indicators were averaged for a composite index (Cronbach’s $\alpha = .85$), with higher scores indicating greater levels of socio-political and economic development.

GINI index. As economic inequality was strongly related to public health (Torre & Myrskyla, 2014; Vincens & Stafstrom, 2015), particularly the COVID-19 pandemic (Elgar et al., 2020; Liao & De Maio, 2021; Oronce et al., 2020), Gini index was controlled.

Cultural factors. As cultural factors predicted COVID-19 severity (Canatay et al., 2021; Gelfand et al., 2021; Gokmen et al., 2021; Maaravi et al., 2021; Schopf, 2022), their effects were accounted for. First, Hofstede’s collectivism (the original individualism index
was multiplied by \(-1\) and power distance indices (Hofstede, n.d.) were controlled. As Hofstede’s collectivism index was developed decades ago, the most recently developed Global Collectivism Index (GCI) (Pelham et al., 2022) was also controlled. As the cultural tightness-looseness indices in Gelfand et al. (2011) and Uz (2015) were only available for a limited number of countries/territories, this study decided to average their Z-transformed scores (Uz’s scores were reversed in the present study; \(r = .53, p = .001\)) for a composite cultural tightness-looseness index, which was available for 85 countries/territories.

**COVID-19 policy response and COVID-19 test-to-case ratio.** According to recent studies (Jia et al., 2021; Sorci et al., 2020), the Government Response Stringency Index (Hale et al., 2021), which captures the effect of COVID-19 policy stringency on COVID-19 control (Hale et al., 2021), was taken from the Oxford COVID-19 Government Response Tracker. To control for under-reporting (Gelfand et al., 2021), COVID-19 test-to-case ratio was calculated by sourcing data on COVID-19 tests and cases from the closest available date.

**Statistical approach**

First, multiple regression analysis was conducted. Second, this study employed multilevel analysis to account for spatial autocorrelation by nesting countries/territories within geopolitical regions defined by the United Nations (https://unstats.un.org/unsd/methodology/m49/) (Kusano & Kemmelmeier, 2020). An unconditional multilevel model specifying the geopolitical regions as a random intercept was calculated. The Intraclass Correlation Coefficient (ICC) was used to determine how much of the proportion of variance in COVID-19 severity was accounted for by the geopolitical regions to justify the use of multilevel analysis. Next, a basic multilevel model with all covariates was calculated (Model 1). Two full multilevel models were calculated to examine the unique effects of religion diversity (Model 2a) and religious interest (Model 2b) on COVID-19 severity, respectively. All analyses were conducted using two-tailed tests. The OSM presents the equations describing the multilevel models.

**Results**

As shown in Fig. 1 (and Table S2), the variables had small (power distance) to large (cultural tightness) correlations with COVID-19 severity.

As visualized in Fig. 2, the religiosity indices showed medium negative associations with COVID-19 severity. When controlling for all covariates in multiple regression analyses, religion diversity, \(B = -0.97, p = .011\), and religious interest, \(B = -0.67, p = .021\), significantly and negatively predicted COVID-19 severity (Table S3). Fig. 3 shows that compared with other predictors, religiosity indices had larger effects on predicting COVID-19 severity.

Next, an unconditional multilevel model with geopolitical regions as a random intercept and COVID-19 severity as a dependent variable showed an ICC = 0.803 and a significant LRT = 137, \(p < .001\). Thus, multilevel analysis was conducted to address the issue of spatial autocorrelation. Table S4 shows that religion diversity (Model 2a), \(B = -0.80, df = 61.70, p = .017\), and religious interest (Model 2b), \(B = -0.60, df = 60.59, p = .025\), significantly predicted COVID-19 severity, after accounting for all covariates. Additionally, test-to-case ratio and cultural tightness negatively and significantly (all \(p < .01\); Table S4) predicted COVID-19 severity across all analyses, suggesting that the uneven spatial distribution of COVID-19 severity was explained by multiple factors.

Accordingly, findings in Study 1a were consistent with the American findings in Ma and Ye (2021b), which supported the anti-pathogen function of heightened religiosity (Fincher & Thornhill, 2008, 2012). As daily-level COVID-19 epidemiological data were available, this research proceeded to examine the effect of macro-level religiosity on daily-level COVID-19 severity.

**Study 1b**

By conducting multilevel analysis on longitudinal epidemiological data (Kafetsios, 2021), Study 1b tested whether macro-level religiosity would negatively predict daily-level COVID-19 severity across countries/territories. Table S5 summarizes the variables examined in this study (see OSM). The OSF folder contains the research data.
Fig. 2. Scatter plots for the relationship between religiosity and COVID-19 severity in Study 1a.

a. A scatter plot for the relationship between religion diversity and COVID-19 severity

b. A scatter plot for the relationship between religious interest and COVID-19 severity
Fig. 3. Standardized betas in multiple regression analyses in Study 1a.

a. Standardized betas in a multiple regression analysis testing the effect of religion diversity on COVID-19 severity

b. Standardized betas in a multiple regression analysis testing the effect of religious interest on COVID-19 severity
a. Standardized betas in a multilevel analysis testing the effect of country-level religion diversity on daily-level COVID-19 severity

b. Standardized betas in a multilevel analysis testing the effect of country-level religious interest on daily-level COVID-19 severity

Fig. 4. Standardized betas in multilevel analyses in Study 1b.
Methods

Countries/territories and time series data

Time series data were sourced from Our World in Data (as accessed on July 23, 2021) for the countries/territories examined in Study 1a. For each country/territory, Study 1b set the first day with at least 20 confirmed cases as the onset of the pandemic (Schopf, 2022). Therefore, the multilevel dataset contained a total of 83,939 time units for 184 countries/territories. Then, the multilevel dataset was split into 12 sub-datasets. Each sub-dataset contained a 25-day pandemic stage (i.e., the first sub-dataset contained the pandemic stage of Day 1–25, while the last sub-dataset contained the pandemic stage of Day 276–300). Therefore, this study examined the effects of religiosity indices on COVID-19 severity in each of the pandemic stages (Schopf, 2022). This research calculated each of the 25-day stages for all countries/territories based on their own onsets of the pandemic. For example, the date for Hong Kong’s initial pandemic day was on March 19, 2020. Thus, the first 25-day pandemic stage in Hong Kong was from March 19 to April 12, and the second 25-day pandemic stage was from April 13 to May 7, and so on.

Measures

Daily-level variables

COVID-19 severity index. According to recent studies (Du et al., 2020; Kafetsios, 2021), COVID-19 time series epidemiological data (i.e., daily data) were log-transformed and standardized. Then, a composite score was calculated by averaging reproductive rate, morbidity, and mortality rates, with higher scores indicating greater levels of COVID-19 severity.

Covariates. First, COVID-19 severity index in the preceding day (day t−1) was controlled to rule out the temporal autocorrelation structure of the dependent variable (Alper, 2019; Ma, 2022; Ma & Ye, 2021a; Pelham et al., 2018). Second, day was controlled to account for time-trend effect on the outcome variable. Moreover, winter days were coded as 1 and non-winter days were coded as 0 to account for the effect of season on COVID-19 severity (Liu et al., 2021; Merow & Urban, 2020; Wu et al., 2020). Furthermore, the government stringency index, which reflected COVID-19 severity (Hale et al., 2021), was controlled.

Country-level variables. Country-level variables in Study 1a were examined.

Statistical approach

Multilevel models are appropriate for analyzing the longitudinal COVID-19 epidemiological data which do not have the same frequency of time units for every country/territory (Kafetsios, 2021). Thus, this research calculated multilevel models which treated days as the repeated observations (Level-1) within each country/territory (Level-2). First, an unconditional model with countries/territories as a random intercept was calculated to estimate how much of the proportion of variance in the daily-level COVID-19 severity could be accounted for by the country-level unit (cluster) membership (Lorah, 2018). Then, a daily-level model (Model 1) controlling for all daily-level covariates was calculated. Next, the effects of all daily- and macro-level covariates were considered (Model 2a). Finally, two full multilevel models with the effects of religion diversity (Model 2b) and religious interest (Model 2c) were calculated, respectively. Finally, this study tested the effects of macro-level religiosity indices on daily-level COVID-19 severity in each of the 25-day pandemic stages by controlling for all daily- and macro-level covariates. Two-tailed tests were conducted. The OSM shows the equations describing the multilevel models.

Results

As the unconditional model with countries/territories as a random intercept showed an ICC = 0.505 and a significant LRT = 42,237, p < .001, multilevel analyses were conducted. Before proceeding to the main analyses, Study 1b conducted two multilevel analyses which controlled for time-trend effect and autoregressive component of the dependent variable only to test the effects of macro-level religiosity indices on daily-level COVID-19 severity. By doing so, the effects of country-level religiosity indices on daily-level COVID-19 severity could be estimated for as many countries/territories as possible, because the availability of data on the covariates in the main analyses varied across countries/territories. It was found that religion diversity, B = −0.01, df = 146.22, p = .028, and religious interest, B = −0.003, df = 170.80, p = .10, negatively and significantly predicted daily-level COVID-19 severity.

Next, the main multilevel analyses were conducted by controlling for all daily and macro-level covariates (Table S6), showing that religion diversity (Model 2b), B = −0.11, df = 61.91, p = .011, and religious interest (Model 2c), B = −0.07, df = 63.62, p = .015, significantly and negatively predicted daily-level COVID-19 severity. Fig. 4 shows that religious interest had a relatively larger effect on predicting the daily changes in COVID-19 severity than did religion diversity. Compared with Model 2a which did not consider the effects of religiosity indices (ICC = 0.0175), the ICC values of the models which considered the effects of religiosity indices (Models 2b and 2c) were smaller (ΔICCs were approximately 0.2%). That is, approximately 1.56% to 1.58% of the total variance in daily-level COVID-19 severity was due to country membership when the effects of religiosity indices and covariates were considered. These findings revealed that a persistent difference in religiosity between countries/territories explained a persistent difference in daily changes in COVID-19 severity.

Next, the effect of religiosity on COVID-19 severity in each pandemic stage was examined. Table S7 shows that religion diversity had a significant and negative effect on COVID-19 severity in Day 101–125, B = −0.18, df = 4.19, p = .040, Day 226–250, B = −0.72, df = 52.59, p = .011, and Day 251–275, B = −0.81, df = 53.25, p < .001, suggesting that extrinsic religiosity predicted COVID-19 reduction
in later pandemic stages. Moreover, Table S8 shows that the negative effect of religious interest on COVID-19 severity was significant in Day 1–25, $B = -0.46, df = 54.36, p = .034$, Day 26–50, $B = -0.86, df = 37.99, p < .001$, Day 51–75, $B = -3.09, df = 68.64, p < .001$, Day 76–100, $B = -0.35, df = 30.53, p = .001$, and Day 101–125, $B = -0.16, df = 18.57, p = .039$, suggesting that intrinsic religiosity contributed to COVID-19 reduction during early pandemic stages.

Accordingly, findings in Study 1b supported the anti-pathogen function of heightened religiosity (Fincher & Thornhill, 2008, 2012) and provided knowledge on the effects of religiosity (extrinsic vs. intrinsic) on predicting daily-level COVID-19 severity in each of the 25-day pandemic stages (Schopf, 2022). As the American findings in Ma and Ye (2021b) showed that heightened religiosity was a BIS reactive response, further examining whether heightened COVID-19 threat would contribute to increases in religiosity across the globe was worthwhile.

**Study 2**

Study 2 was conducted to examine the effect of COVID-19 threat (actual vs. perceived) on religious searches at weekly level to test the hypothesis that religiosity was a BIS reactive response to heightened COVID-19 threat (Ma & Ye, 2021b). Table S9 summarizes the variables examined in this study (see OSM). The OSF folder contains the data analyzed in this study.

**Methods**

_Countries/territories and time series data_

Countries were those examined in Study 1. Considering that it was not able to acquire daily-level Google Trends data for periods longer than 10 months, this study focused on the weekly-level data, which are available for a 5-year period (Alper, 2019). Thus, this study examined a total of 80 consecutive weeks (from January 5, 2020 to July 17, 2021) for each of the 189 countries/territories (Internet query data were unavailable for Eritrea and Monaco), yielding a multilevel dataset of 15,120 time units.

**Measures**

_Weekly-level variables_  
COVID-19 severity index. Study 2 calculated the 7-day average COVID-19 severity index from the daily data in Study 1b to capture weekly-level COVID-19 severity.  

_Google Trends indices_. The data collection approaches detailed in Study 1a were followed to create Google Trends measures, namely, religious interest index, perceived coronavirus threat index, and major illness index. Specifically, the major illness index was used to partial out the effect of terror management on religious searches (Alper, 2019; Pelham et al., 2018). In addition, Study 2 used control search terms for robustness checks (English et al., 2022). According to one of the review comments and for consistency with Study 1, Study 2 calculated the per capita Google Trends measures (see Study 1a). As in recent studies (Du et al., 2020; Rangarajan et al., 2019; Yang et al. 2015), Google Trends time series measures were log-transformed.

_Keyword selection_. The World Factbook (https://www.cia.gov/the-world-factbook/) was used to determine the predominant religion of each country/territory. Then, religious search terms which belonged to the targeted religions were used as search keywords (see Study 1a). For example, the Christianity-related topic search terms (e.g., God, Jesus, Prayer) were used for tracking religious searches at weekly level for Christian-majority countries/territories.  

According to recent studies (Ma, 2022; Ma & Ye, 2021a, 2021b, 2022), the exact search terms corona, covid, covid19, covid 19, and covid-19 and the topic search term Coronavirus were used to assure the reliability and validity of the perceived coronavirus threat index. Moreover, the topic search terms Cancer, Hypertension, and Diabetes were used to create a major illness index, because searching for such keywords could increase death-thought accessibility, which predicted religious searches (Alper, 2019; Pelham et al., 2018).

Additionally, the topical search terms Calendar, Calculator, Weather and the exact search term Whatsapp web (Hudgens, 2022) were used as control search terms (English et al., 2022). These keywords were selected because some popular search terms, such as Map (English et al., 2022), could capture the public attention towards specific topics. For example, the top five related queries of the topic search term Map between January 5, 2020 and July 17, 2021 were coronavirus map, covid map, covid 19 map, mapa coronavirus, and corona karte (see https://trends.google.com/trends/explore?date=2020-01-05%202021-07-17&q=%2Fm%2F04_tb). Therefore, although Map is a common search term (English et al., 2022), searching for Map during the pandemic could partly capture people’s attention towards COVID-19.

_Region and period selection_. This study tracked the weekly RSV scores for each of the countries/territories examined in Study 1. The time frame for Google Trends data retrieval was from January 5, 2020 to July 17, 2021.

_Search categories_. No categories or subcategories were selected for the searches to filter the results to a certain category.

_Religious interest index_. For Christian countries/territories, the Christianity religious interest index was created by averaging the RSV scores of Prayer, Jesus, and God (Cronbach’s $\alpha = .64$ across weeks). For Islamic countries/territories, the Islam religious interest index was computed by averaging the RSV scores of Allah, Prophet, and Ayet (Cronbach’s $\alpha = .60$ across weeks). For countries/territories predominated by Buddhism, the Buddhism religious interest index was calculated by averaging the RSV scores of Buddhism, Buddha, Bodhisattva, and Zen (Cronbach’s $\alpha = .79$ across weeks). For countries/territories predominated by Hinduism, the Hinduism religious interest index was created by averaging the RSV scores of Hinduism, Vedas, and Atman (Cronbach’s $\alpha = .71$ across weeks). For countries/territories predominated by Judaism, the Judaism religious interest index was computed by averaging the RSV scores of Torah,
Tanakh, and Talmud (Cronbach’s α = .55 across weeks). In the multilevel dataset, each of the religious indices belonged to the variable religious interest index.

**Perceived coronavirus threat index.** The coronavirus-related RSV scores were averaged for a perceived coronavirus threat index (Cronbach’s α = .89 across weeks), with higher scores indicating higher levels of perceived coronavirus threat. The measurement validity of the present measure was supported in recent studies (Ma, 2022; Ma & Ye, 2021a, 2022).

---

**Fig. 5.** Partial correlation between COVID-19 threat and religious interest in the present week (week t) in each country/territory in Study 2. Note. The partial correlation analysis controlled for preceding-week religious interest index, time-trend effect, season, religious holiday, stringency index, and major illness index.

*a.* Partial correlation between perceived coronavirus threat index and the present-week (week t) religious interest index in each country/territory.

*b.* Partial correlation between COVID-19 severity index and the present-week (week t) religious interest index in each country/territory.
Other Google Trends measures. Other Google Trends measures included 1) major illness index, which was calculated by averaging the RSV scores of Cancer, Diabetes, and Hypertension (Cronbach’s $\alpha = .70$ across weeks), and 2) the four control search terms.

Other weekly-level variables. COVID-19 stringency index. As COVID-19 stringency index was closely related to COVID-19 severity index at daily level (see Table S6), the 7-day average stringency index was controlled.

Autocorrelation, time-trend effect, season, and religious holidays. Autocorrelation was controlled by accounting for the effect of religious interest index in the preceding week (week $t - 1$). Time-trend effect was accounted for by controlling for week. As COVID-19 was more severe during winter (see Table S6), winter weeks were coded as 1 and non-winter weeks were coded as 0 to account for the seasonal effect of COVID-19 on religious searches. As it was expected that people would be more religious during religious holidays (Pelham et al., 2018), the effect of religious holiday was controlled (Ma, 2022; Ma & Ye, 2021a). According to recent studies (Ma, 2022; Ma & Ye, 2021a, 2022), religious holidays were identified according to the predominant religion of each country/territory (i.e., Easter and Christmas days for Christianity; Ramadan, Eid Al Fitr, and Eid Al Adha for Islam; Diwali for Hinduism; Buddha’s Birthday for Buddhism; Passover for Judaism). For each country/territory, religious weeks were coded as 1 and non-religious weeks were coded as 0.

Fig. 6. Standardized betas of weekly-level predictors of the present-week (week $t$) religious interest index in multilevel models in Study 2.
Country-level variables

Country-level variables were those examined in Study 1b. As suggested by one of the reviewers, Christian countries/territories, compared with non-Christian countries/territories, was expected to have more religious searches, given that Christianity is faith-focused (e.g., believing God’s promises) (Ballard, 2011; Mckaughan, 2018). Accordingly, the macro-level variable Christian country/territory (1 = non-Christian country/territory, 2 = Christian country/territory) was examined.

Statistical approach

First, Kendall’s τ correlation analysis was conducted to examine the relationships between the weekly time series (Malyev et al., 2021; Preis et al., 2013). Next, all weekly covariates were controlled in a partial correlation analysis to test the relationship between COVID-19 threat (actual vs. perceived) and present-week religious interest index in each country/territory. Then, multiple regression analysis was conducted to examine the effect of COVID-19 threat on present-week religious interest index, controlling for all weekly-level covariates.

As the weekly data were nested within countries/territories, multilevel models were calculated (Ma & Ye, 2021a, 2021b). In the multilevel models, the intercept representing the mean religious interest index in the present week (Level-1) was allowed to vary randomly by countries/territories (Level-2). First, an unconditional model was calculated to examine how much of the proportion of variance in weekly religious interest was accounted for by the country/territory membership (Lorah, 2018). Next, a weekly-level model was calculated to examine the effects of weekly-level predictors on the present-week religious interest index (Weekly-level Model), controlling for all weekly covariates. Then, a full model was calculated to examine the effects of all weekly- and macro-level predictors on religious searches (Full Model). According to English et al. (2022), the methodological artifacts of search data were ruled out by conducting multilevel analyses on a set of common search terms not related to religiosity (e.g., Calculator). The OSM presents the equations describing the multilevel models.

Results

Table S10 shows that religious interest index had significant and positive correlations with its autoregressive component, Kendall’s τ = .75, p < .001, perceived coronavirus threat index, Kendall’s τ = -.57, p < .001, COVID-19 severity index, Kendall’s τ = -.02, p = .002, and major illness index, Kendall’s τ = -.73, p < .001. Table S11 shows that perceived coronavirus threat index and COVID-19 severity index had positive correlations with religious interest index in 156 and 120 countries/territories, respectively. Fig. 5 (and Table S12) shows that after controlling for all weekly-level covariates, COVID-19 threat indices still had positive relationships with religious searches in most countries/territories.

Next, as an unconditional multilevel model showed an ICC = 0.554 and a significant LRT = 11,308, p < .001, multilevel analyses were conducted. Table S13 shows that controlling for all weekly-level covariates did not alter the significant and positive effect of perceived coronavirus threat on religious interest (Weekly-level Model), B = 0.04, df = 11,671.83, p < .001, but the effect of actual COVID-19 severity was non-significant, B = 0.003, df = 11,514.31, p = .245. Fig. 6a shows that the effect of perceived coronavirus threat on religious interest was larger than the effect of actual COVID-19 threat. After accounting for both weekly- and macro-level covariates (Full Model), the effect of perceived coronavirus threat on religious interest remained significant, B = 0.03, df = 4931.23, p < .001, while the effect of actual COVID-19 severity was marginally significant, B = 0.01, df = 4894.23, p = .050. In the final model, the effect of perceived coronavirus threat on religious interest was still larger than the effect of actual COVID-19 severity (see Fig. 6b). Additionally, the effects of preceding-week religious interest index, religious holiday, COVID-19stringency index, and major illness index on the present-week religious interest index were significant and positive across models (all p < .001; see Table S13).

At macro level, the persistent differences in the levels of disease richness, socio-political and economic development, test-to-case ratio, Hofstede’s collectivism, country-level religiosity, and Christian country/territory explained the systematically cross-country differences in weekly religious searches during the pandemic (all p < .05; see Table S13). For example, as Christianity is faith-focused (Ballard, 2011; Mckaughan, 2018), Christian countries/territories had more religious searches during the pandemic, B = 0.17, df = 43.52, p = .020, than non-Christian countries/territories. Moreover, intrinsic religiosity (i.e., country-level religious interest index) had a positive effect on weekly religious searches, B = 0.36, df = 43.65, p = .048, while religion diversity index negatively predicted weekly religious searches, B = -0.59, df = 44.56, p = .019. These findings were consistent with the proposal that intrinsic religiosity motivates people to integrate religious beliefs in their daily lives, while extrinsic religiosity does not capture the central religious beliefs per se (Allport & Ross, 1967; Power & McKinney, 2014).

To account for the methodological artifacts of online query data (English et al., 2022), the dependent variable in the multilevel models was replaced by each of the four common search terms. Table S14 shows that perceived coronavirus threat did not significantly predict the present-week RSV scores of Calendar, B = -0.01, df = 2743.00, p = .737, Calculator, B = -0.01, df = 4823.28, p = .122, Weather, B = -0.01, df = 1199.55, p = .191, and WhatsApp, B = -0.01, df = 4347.70, p = .536, after accounting for all weekly- and macro-level covariates. Although major illness index, compared with perceived coronavirus threat index, had a relatively larger effect on predicting religious searches (see Fig. 6), major illness index significantly and positively predicted common searches (all p < .001; see Table S14). Thus, searching for major illnesses predicted more searches in general (English et al., 2022), not only for religious searches (Aliper, 2019; Pelham et al., 2018).

Accordingly, findings in Study 2 supported the hypothesis that heightened religiosity was responsive to heightened perceived coronavirus threat, suggesting that heightened religiosity was a BIS reactive response during the pandemic (Ma & Ye, 2021b).
Discussion

The present research extends the American findings in Ma and Ye (2021b) by showing that 1) highly religious countries/territories have better control of COVID-19, and 2) heightened perceived coronavirus threat contributes to increases in religiosity. Such findings provide insights into the anti-pathogen function of heightened religiosity (Fincher & Thornhill, 2008, 2012) and the social implications of the COVID-19 pandemic (Ma, 2022; Ma & Ye, 2021a, 2021b).

Findings in Study 1 reveal that heightened religiosity is a BIS proactive response, which could proactively avoid and manage pathogen risks (Ackerman et al., 2018). Although religious gathering could increase the transmissible risk of COVID-19 during early pandemic stages (Lee et al., 2021), other religious practices, such as bodily cleanliness (Allegranzi et al., 2009; Jaglzarz, 2013), contribute to the control of the novel coronavirus (Barmania & Reiss, 2021; Przekwas & Chen, 2020). As searching for religion-related terms reflects religious internalization, it is likely that people in countries/territories with more religious searches are intrinsically motivated to adhere to those religiously prescribed norms of healthy behaviors (e.g., physical purity and cleanliness) and healthy lifestyles (e.g., prohibition on drug abuse) (Allegranzi et al., 2009; Barmania & Reiss, 2021; Jaglzarz, 2013) as well as in-group pro-sociality (Preston & Ritter, 2013; Purzycki & Kulundary, 2018; Willard et al., 2020) than people in countries/territories with less religious searches. Therefore, Study 1 shows that intrinsic religiosity (i.e., religious searches) has a significant and negative effect on COVID-19 severity during early pandemic stages. As religion diversity only shows a significant and negative effect on COVID-19 severity in the fifth, tenth, and eleventh pandemic stages, the mitigating effects of extrinsic religiosity on COVID-19 severity are less consistent than intrinsic religiosity. Given that heightened intrinsic religiosity motivates people to live their religions for purity and sanctity (Allport & Ross, 1967; Power & McKinney, 2014), it is likely that intrinsic religiosity could mitigate the devastating effect of COVID-19, particularly during early pandemic stages.

Given that religion is a drive of moral judgments (Hone et al., 2020; Kirchmaier et al., 2018; Minton et al., 2019; Willard et al., 2020), heightened religiosity promoted strong moral concerns (Hone et al., 2020; Kirchmaier et al., 2018; LaBouff et al., 2017; Minton et al., 2019; Willard et al., 2020), which denote a reactive BIS (i.e., highly responsive to pathogen threat). Thus, the anti-pathogen function of heightened religiosity could be partly attributed to the disease-avoidance functions of strong moral concerns (Makhnova et al., 2019; Van Leeuwen et al., 2017, 2012), which contributed to the prevention of COVID-19 (Lo Presti et al., 2022; Pagliaro et al., 2021). Apart from the moral foundation perspective, another explanation could be derived from the closely intertwined relationships between religiosity and social focus personal values (Chan et al., 2020; Colledani, 2017; Roccas & Elster, 2014; Saroglou et al., 2004; Saroglou & Muñoz-García, 2008). As personal values are the guiding principles of human behaviors (Schwartz, 1994, 2012), people who attach importance to social focus values will show more self-sacrificial and prosocial behaviors (Schwartz, 1994; Schwartz et al., 2012). Thus, prioritizing social focus values contributes to the control of COVID-19 (Bonetto et al., 2021; Lake et al., 2021; Ma, 2021a; Wolf et al., 2020). Interestingly, religiosity showed a consistently positive relationship with the social focus values of benevolence but not universalism (Roccas & Elster, 2014; Saroglou et al., 2004; Saroglou & Muñoz-García, 2008). This finding supports the group-focused orientation of heightened religiosity (Fincher & Thornhill, 2012), given that benevolence values focus on caring for the close others; meanwhile, universalism values focus on tolerating and protecting out-group individuals (Roccas & Elster, 2014; Schwartz, 1994).

In addition, Study 1 replicates the significant and negative effect of cultural tightness on COVID-19 severity (Gelfand et al., 2021; Schopf, 2022). Thus, cultural tightness could also be a BIS proactive response, given that norm similarity distinguishes in-group from out-group (Fincher & Thornhill, 2012) for disease-avoidance (Gelfand et al., 2011; Harrington & Gelfand, 2014). Although higher levels of collectivism are documented to contribute to COVID-19 control (Gokmen et al., 2021; Lu et al., 2021; Ma & Ye, 2021b; Maaravi et al., 2021; Webster et al., 2021), the present research shows that compared with religiosity and cultural tightness, the effect of collectivism on predicting COVID-19 severity is less prominent. As collectivism is a broad and general concept characterized by various characteristics (Brewer & Chen, 2007; Talhelm & English, 2020), going beyond collectivism to focusing on more precise traits (Vignoles et al., 2016) could support a more specific effect of in-group assortative sociality on pathogen avoidance (Fincher & Thornhill, 2008, 2012; Thornhill & Fincher, 2014c).

Similar to the American findings in Ma and Ye (2021b), Study 2 shows that heightened religiosity is a BIS reactive response to the COVID-19 threat. As perceived coronavirus threat uniquely contributes to religious searches at weekly level, the present research suggests that only when COVID-19 threat is in the consciousness would people become more likely to live their religions. Indeed, COVID-19 literature has documented that compared with actual COVID-19 threat assessed with COVID-19 epidemiological data, perceived coronavirus threat assessed with either self-report or Internet search data is more robust in predicting BIS reactive responses (Adam-Troian & Başci, 2021; Ma, 2022; Ma & Ye, 2021a, 2021b, 2022; Pagliaro et al., 2021). One explanation could be attributed to the evidence that BIS is insensitive to COVID-19 statistics such as morbidity and mortality rates (Bacon & Corr, 2020), suggesting that epidemiological statistics might be insufficiently salient to activate BIS reactive responses. Thus, the present findings support the suggestion in Bonetto et al. (2021) that distinguishing the perceived threat and actual threat is important when testing the effects of coronavirus threat on behavioral changes during the pandemic.

Study 2 also shows that coronavirus-related searches specifically predict religion-related searches but not searches for common terms (English et al., 2022), suggesting that perceived coronavirus threat has unique effects on religiosity during the pandemic. Although searching for major illnesses online positively predicts religious searches, which is consistent with recent studies (Alper, 2019; Pelham et al., 2018), more major-illness-related searches also predict more searches in general (English et al., 2022). Thus, major-illness-related searches could also reflect temporarily active online behaviors. However, some popular search terms, such as Youtube and Facebook (Hudgens, 2022), could also capture important psychological processes in cyberspace. For example, machine-learning analysis revealed that moral foundations and human values could be indicated by the degree to which people visited
specific websites (e.g., Facebook.com) and used specific applications (e.g., YouTube) (Kalimeri et al., 2019). Therefore, weekly fluctuations in online searches for some popular terms might indicate weekly fluctuations in psychological attributes at group level. In this regard, analyzing common search terms for addressing the methodological artifacts of online query data (English et al., 2022) should be carefully conducted by selecting appropriate common search terms which might not tap into other psychological constructs.

This research has several limitations that could be addressed in future studies. First, as religious practices vary across religions, religion diversity was used to proxy extrinsic religiosity at macro level in the present research, suggesting that future studies could employ other measures of extrinsic religiosity to cross-validate the present findings. As suggested by one of the reviewers, extrinsic religiosity is mainly about pray and church service (Allport & Ross, 1967). Thus, it is recommended that future studies might examine whether historical data on church attendance could predict COVID-19 severity. Second, future research could test whether moral foundations (Hone et al., 2020; Kirchmaier et al., 2018; LaBouff et al., 2017; Minton et al., 2019; Willard et al., 2020) and social focus values (Chan et al., 2020; Colledani, 2017; Roccas & Elster, 2014; Saroglou et al., 2004; Saroglou & Muñoz-García, 2008) are the mechanisms through which heightened religiosity mitigates COVID-19 severity. Third, if in-group assortative sociology serves an anti-pathogen function (Fincher & Thornhill, 2008, 2012), other features of in-group assortative sociality could also contribute to COVID-19 control. For example, whether valuing strong family ties, which is another extended element of in-group assortative sociality (Fincher & Thornhill, 2012), would also reactively and proactively respond to COVID-19 at worldwide level remains unknown. Lastly, individual-level research could be conducted to test whether exposure to COVID-19 cues (Chan & Saqib, 2021; Karwowski et al., 2020; Moran et al., 2021; Sorokowski et al., 2020) could increase intrinsic religiosity and promote religious behaviors, which could further support the BIS reactive role of heightened religiosity.

Funding

This research received no specific grant from any funding agency, commercial or not-for-profit sectors.

Acknowledgments

I would like to thank Dr. Alexander English and the two anonymous reviewers for their thoughtful and extensive comments. Thank you very much for your time and energy.

Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ijintrel.2022.07.005.

References

Ackerman, J. M., Hill, S. E., & Murray, D. R. (2018). The behavioral immune system: Current concerns and future directions. Social and Personality Psychology Compass, 12(2), Article e12371. https://doi.org/10.1111/spc3.12371

Adam-Troian, J., & Arciszewski, T. (2020). Absolutist words from search volume data predict state-level suicide rates in the United States. Clinical Psychological Science, 8(4), 788–793. https://doi.org/10.1177/2167702620916925

Adam-Troian, J., & Bagci, S. C. (2021). The pathogen paradox: Evidence that perceived COVID-19 threat is associated with both pro-and anti-immigrant attitudes. International Review of Social Psychology, 34(1), 1–15. https://doi.org/10.5334/irsp.469

Adam-Troian, J., Bonetto, E., & Arciszewski, T. (2021). “We shall overcome”: First-person plural pronouns from search volume data predict protest mobilization across the United States. Social Psychological and Personality Science, 12(8), 1476–1485. https://doi.org/10.1177/1948550620987672

Adolfsen, D. (2014). The role of social media in health promotion: A content analysis. International Journal of Social Research Methodology, 17(2), 153–162. https://doi.org/10.1080/13645579.2013.863300

Alper, S. (2019). Does the association between illness-related and religious searches on the internet depend on the level of religiosity. Social Psychological and Personality Science, 12(4), 497–505. https://doi.org/10.1177/1948550620922323

Alper, S., Bayrak, F., Us, E.O., & Yilmaz, O. (2020). Do changes in threat salience predict the moral content of sermons? The case of Friday Khutbas in Turkey. European Journal of Social Psychology, 50(3), 662–672. https://doi.org/10.1002/ejsp.2632

Ananta, A., & Arifin, E. N. (2021). International population mobility in East Asia. In F. Kimura, M. Pangestu, S. M. Thangavelu, & C. Findlay (Eds.), Handbook on East Asian economic integration. Edward Elgar Publishing.

Arora, V. S., McKee, M., & Stuckler, D. (2019). Google trends: Opportunities and limitations in health and health policy research. Social and Personality Psychology Compass, 12(4), 432–443. https://doi.org/10.1111/spc3.12371

Barmania, S., & Reiss, M. J. (2021). Health promotion perspectives on the COVID-19 pandemic: The importance of religion. Global Health Promotion, 28(1), 15–22. https://doi.org/10.1177/1757975920972992

Barrett, D. B., Kurian, G. T., & Johnson, T. M. (2001). World Christian encyclopedia: A comparative survey of churches and religions in the modern world the world by countries: Religiousists, churches, ministries (2nd ed.). Oxford University Press.

52
Verity, R., Okell, L. C., Dorigatti, I., Winskill, P., Whittaker, C., Imai, N., Cuomo-Dannenburg, G., Thompson, H., Walker, P. G., & Fu, H. (2020). Estimates of the severity of coronavirus disease 2019: A model-based analysis. *The Lancet Infectious Diseases, 20*(6), 669–677. https://doi.org/10.1016/s1473-3099(20)30243-7

Vignoles, V. L., Owe, E., Becker, M., Smith, P. B., Easterbrook, M. J., Brown, R., Gonzalez, R., Didier, N., Carrasco, D., & Cadena, M. F. (2016). Beyond the east–west dichotomy: Global variation in cultural models of selfhood. *Journal of Experimental Psychology: General, 145*(8), 966–1000. https://doi.org/10.1037/xge0000175

Vicens, N., & Stafstrom, M. (2015). Income inequality, economic growth and stroke mortality in Brazil: Longitudinal and regional analysis 2002-2009. *PLoS ONE, 10*(9), Article e0137332. https://doi.org/10.1371/journal.pone.0137332

Webster, G. D., Howell, J. L., Loese, J. E., Mahar, E. A., & Wongsomboon, V. (2021). Culture, COVID-19, and collectivism: A paradox of American exceptionalism. *Personality and Individual Differences, 178*, Article 110853. https://doi.org/10.1016/j.paid.2021.110853

White, E. R., & Hebert-Dufresne, L. (2020). State-level variation of initial COVID-19 dynamics in the United States. *PLoS ONE, 15*(10), Article e0240648. https://doi.org/10.1371/journal.pone.0240648

Willard, A. K., Baimel, A., Turpin, H., Jong, J., & Whitehouse, H. (2020). Rewarding the good and punishing the bad: The role of karma and afterlife beliefs in shaping moral norms. *Evolution and Human Behavior, 41*(5), 385–396. https://doi.org/10.1016/j.evolhumbehav.2020.07.001

Wolf, L. J., Haddock, G., Manstead, A. S., & Maio, G. R. (2020). The importance of (shared) human values for containing the COVID-19 pandemic. *British Journal of Social Psychology, 59*(3), 618–627. https://doi.org/10.1111/bjso.12401

Wu, B.-P., & Chang, L. (2012). The social impact of pathogen threat: How disease salience influences conformity. *Personality and Individual Differences, 53*(1), 50–54. https://doi.org/10.1016/j.paid.2012.02.023

Wu, Q., Tan, C., Wang, B., & Zhou, P. (2015). Behavioral immune system and ingroup derogation: the effects of infectious diseases on ingroup derogation attitudes. *PLoS ONE, 10*(3), Article e0122794. https://doi.org/10.1371/journal.pone.0122794

Wu, Y., Jing, W., Liu, J., Ma, Q., Yuan, J., Wang, Y., Du, M., & Liu, M. (2020). Effects of temperature and humidity on the daily new cases and new deaths of COVID-19 in 166 countries. *Science of the Total Environment, 729*, Article 139051. https://doi.org/10.1016/j.scitotenv.2020.139051

Yang, S., Santillana, M., & Kou, S. C. (2015). Accurate estimation of influenza epidemics using Google search data via ARGO. *Proceedings of the National Academy of Sciences, 112*(47), 14473–14478. https://doi.org/10.1073/pnas.1515273112

Yeung, T. Y.-C. (2019). Measuring christian religiosity by Google trends. *Review of Religious Research, 61*(3), 235–257. https://doi.org/10.1007/s13644-019-00379-w

Zmigrod, L., Ebert, T., Gotz, P. M., & Rentfrow, P. J. (2021). The psychological and socio-political consequences of infectious diseases: Authoritarianism, governance, and nonzoonotic (human-to-human) infection transmission. *Journal of Social and Political Psychology, 9*(2), 456–474. https://doi.org/10.5964/jspp.7297