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RESEARCH ARTICLE

Social Factors and UFO Reports: Was the SARS-CoV-2 Pandemic Associated with an Increase in UFO Reporting?

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HIGHLIGHTS

Analysis shows that an increase in UFO sightings during the 2020 pandemic was merely coincidental and can be explained entirely by sunlight reflected off satellites.

ABSTRACT

The ongoing SARS-Cov-2 pandemic had many drastic effects upon society beyond the illness and death it caused. Pandemic mitigation measures disrupted and altered behaviors related to social mobility, significantly increasing the time spent at home compared to the pre-pandemic period. Further, it was well documented that social anxiety and stress increased at a population level. Early in the pandemic there was speculation in the popular media that reporting of paranormal phenomena (e.g., UFOs, ghosts, etc.) increased due to factors associated with the pandemic. Past research on UFO/UAP reporting has theorized that increases are triggered by social factors, and so the pandemic provided a natural experiment to test these claims. To measure UFO reports we utilized two public databases of UFO reports for sightings in the United States, provided by the National UFO Reporting Center and the Mutual UFO Network. To estimate the impact of the pandemic we utilized two measures, one for social mobility and one for pandemic/disease severity. Google Community Mobility Reports provided a metric of social mobility for people who use Google Maps on their cellular telephone (i.e., amount of time spent at work compared to home), which we aggregated to a state level to estimate time spent at home. Second, we used new weekly SARS-CoV-2 cases and deaths, both absolute counts and per capita, which can be considered to be an indirect measure of anxiety and stress. We find that UFO reports did increase in 2020 compared to 2019 ($p < 0.001$ for both databases); however, the level of UFO reporting had little to no association with the various pandemic-related measures, offering no support for hypothesized social factors that influence reporting. A complicating factor in UFO reporting is the start in 2019 of Starlink satellite launches. These launches include up to 60 small satellites at once, and so are very distinctive and often easily visible. As a result, many people report these as UFOs. We coded and removed these reports from the sighting databases, and the filtered data similarly have no association with the pandemic-related factors. Further, with Starlink reports removed, there was no increase in sightings in 2020 compared to 2019. Our results contribute to an understanding of large-scale factors that impact the reporting of paranormal events, especially timely given the renewed public and government focus on the UFO phenomenon today.

KEYWORDS

UFO reports, UAP reports, SARS-Cov-2 pandemic, MUFON, NUFORC , Starlink

INTRODUCTION

The Coronavirus 2019 (SARS-CoV-2) pandemic has been a great disruptor of societies worldwide, in almost all activities. The pandemic caused many places of work, and most schools, to shut down in almost every Western nation, and these closures continued into 2021. The direct effects of SARS-CoV-2 have been the illnesses and deaths and long-term problems suffered by those infected. The shutdowns and restrictions, as well as general anxiety caused by the pandemic, have led to other deleterious outcomes, including an increase in suicide, depression, problems sleeping, financial difficulties, and social isolation. The restrictions and office and school closures led to changes in the time people spent at home versus away from home, often causing complications for those without adequate household space to conduct work, family, and home tasks.

The effect of the pandemic was not necessarily limited to the more mundane, day-to-day, activities in society. By the spring of 2020, shortly into the pandemic, speculation began about whether there was an increase in reports of ghosts, or of Unidentified Flying Objects (UFOs) (Heaney, 2020; Stevens, 2020), which was quickly picked up by the mainstream press (Jett, 2021; Nir, 2021). This was too soon for any reliable statistics, but the conjecture was based, in part, on the idea that people were home, with more time available to experience odd phenomenon. Additional speculation posited that the increased levels of pandemic-induced anxiety reported at a population level (Peteet, 2020; Salari et al., 2020) could lead to a heightened awareness to events and occurrences that were previously ignored.

In this work, we attempt to provide an answer to this question using UFO reports as the test case. Advantages of using UFO reports include a) thousands of reports are made every year, providing sufficient data; b) fairly rapid reporting by witnesses so that reporting lag is not a serious limiting factor; and c) open access to reporting databases. In this research we use UFO sightings within the United States (US) as the civilian-based UFO reporting apparatus is comprehensive and robust.

The number of yearly UFO reports in the US has not been constant, varying by a factor of 10 in reports to the official US Air Force UFO projects, from 1947 to 1969 (Sparks). That trend has continued since then in sightings collected by civilian groups, including the Mutual UFO Network (MUFON) and the National UFO Reporting Center (NUFORC). Large increases in UFO reports, such as occurred in November 1957, or the fall of 1973, have been termed "waves" by UFO researchers. Waves are, according to Bullard (1998), ". . . any notable and temporary rise in UFO reports above the usual rate." He notes the important question of ". . . whether waves mean heightened UFO activity or just heightened publicity and public awareness without more UFOs . . . "

We emphasize that, in this research, we take no position on the various hypotheses for the source of UFO reports—the phenomena that people witnessed that caused them to make a report. UFO groups such as MUFON investigate reports and, in the broadest sense, classify them as identified by a known phenomenon (stars, aircraft, etc.), or unidentified (with a third category of insufficient information to make an identification). We are interested here in the simple fact that a report was made by a person, regardless of classification.

In Figure 1 (upper panel), we display the number of UFO reports submitted to the NUFORC website (www.nuforc.org) over time, by week. We note that prior to the existence of the NUFORC website, they collected reports via telephone, however these reports are not included in their public database. In Figure 1 (lower panel), we present a more recent look at the reports, by week, smoothed with a 25-period moving average, to examine overall trends in the NUFORC database. We draw attention to four features in Figure 1: 1) in general, UFO reports trended down from 2014 to 2019; 2) contrary to what has been reported in the popular media (Jett, 2021; Nir, 2021), the increase in the number of UFO reports began well before the pandemic; 3) the seasonal effects that are present in prior years (reports peak in the summer when more people are outside), diminish over time beginning in 2017; and 4) reports peak early in the late winter of 2020. Though only three years of data were available from the MUFON database, precluding the assessment of longer-term trends, the mid-year peak is evident in both 2018 and 2019, while it is shifted early to the late winter in 2020 (see Figure 2). In Figure 3 we compare the number of reports submitted to NUFORC (black) and MUFON (grey) in 2018–2020 to visually assess the concordance between the number of reports. While similar, there are clearly differences between them, with the Pearson correlation between the two series of 0.58 ($p < 0.001$). Each database will act as a separate test for the effects of the pandemic.

Past UFO waves led to intense press interest, and the public became aware that others were reporting UFOs (Jacobs, 1976). This did not occur during the pandemic: There were not media reports of very large increases of reports across the US, despite the initial speculation, and UFO organizations themselves did not comment on increased reporting. From this we can conclude that a 'classic' UFO wave did not happen, but that does not preclude a change in the number of reports that is less dramatic but still substantial.

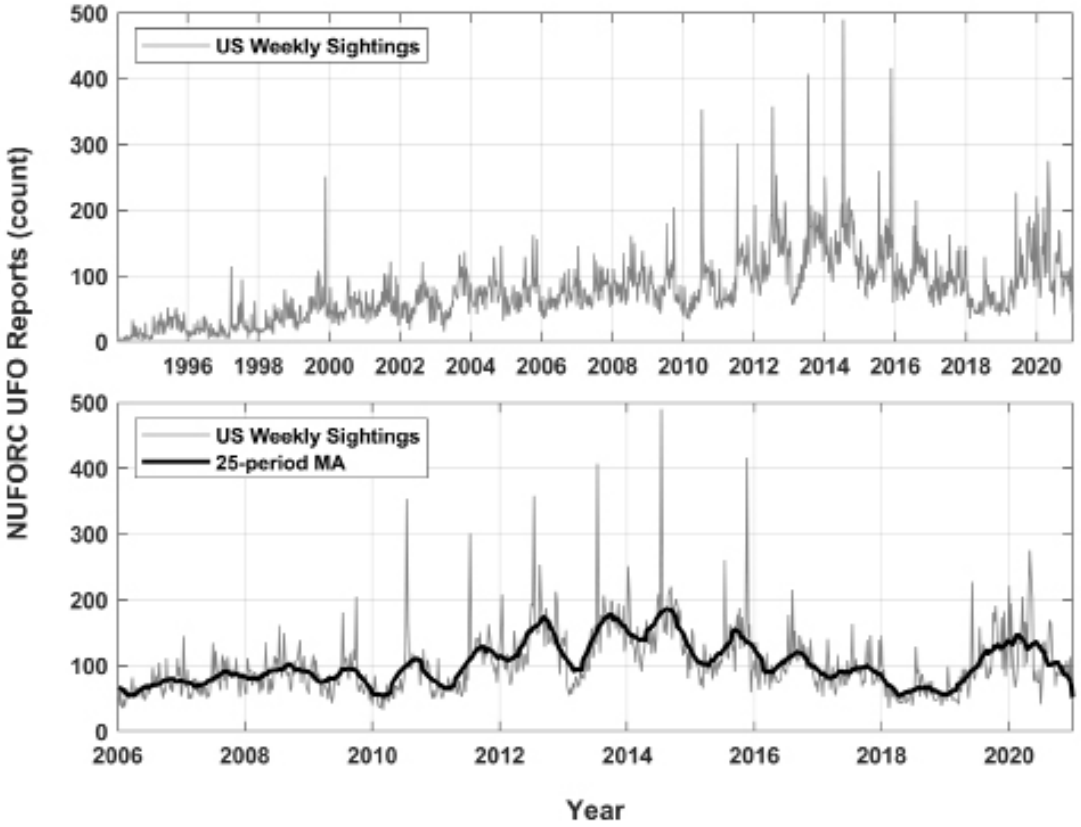

Figure 1. UFO reports submitted to NUFORC. Upper panel: Weekly count of Unidentified Flying Object (UFO) reports submitted to the National UFO Reporting Center (NUFORC), from 1/1/1994 to 12/31/2020. In general, we note that there is typically a clear seasonal effect to report counts, with reporting peaking in the summer. Lower panel: Weekly count of UFO reports submitted to NUFORC from 1/1/2006 to 12/31/2020 (grey) with the 25-period moving average overlayed on the plot in black.

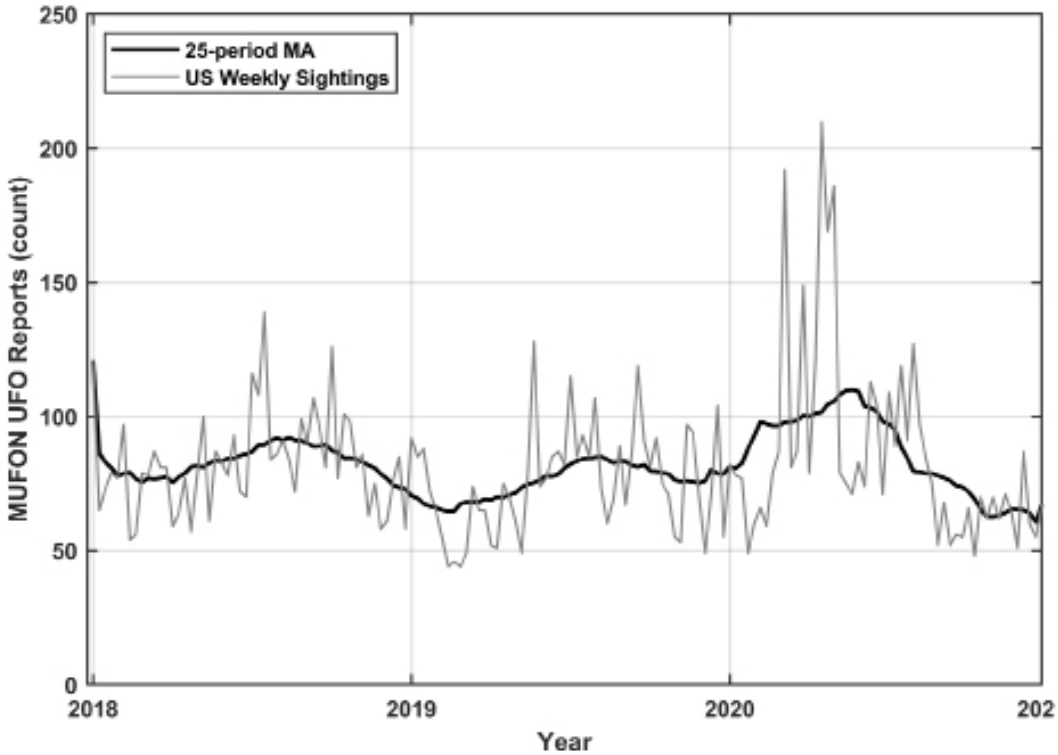

Figure 2. UFO reports submitted to MUFON. The weekly count of UFO reports submitted to the Mutual UFO Network (MUFON) from 1/1/2018 to 12/31/2020 in grey with the 25-period moving average overlayed on the plot in black.

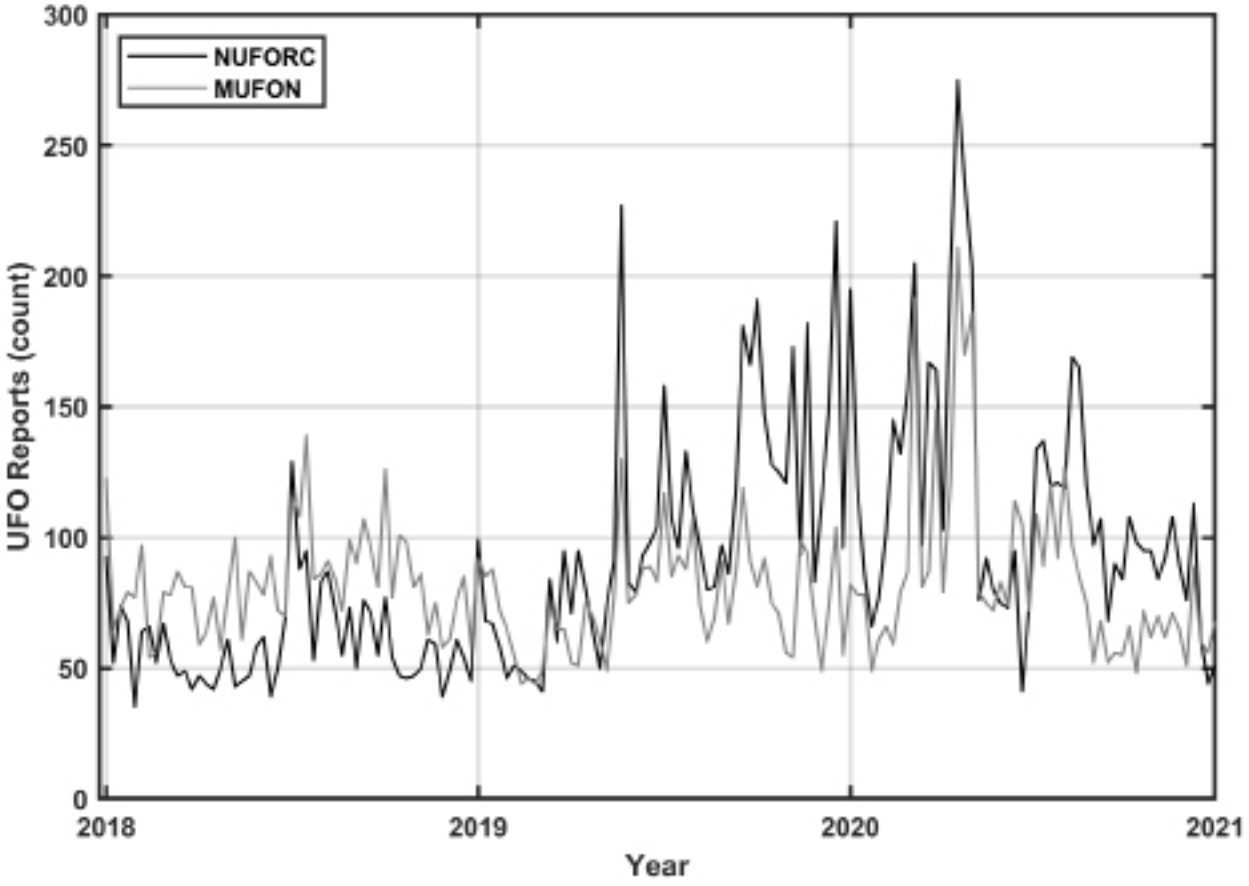

Figure 3. Comparison of UFO reports submitted to NUFORC and MUFON. The black line depicts weekly count of UFO reports submitted to NUFORC and the grey line depicts weekly count of UFO reports submitted to MUFON from 1/1/2018 to 12/31/2020.

Influences on UFO Reporting Dynamics

A UFO report results from one or more people who are in position to observe something unusual (to them), and who then are both motivated to report the experience, and have opportunity to do so (Westrum, 1977). The chief factors related to this process are listed in Figure 4. The proximate factors influencing the number of reports include the following:

1) **Number of phenomena.** People who report UFOs generally have seen *something* in the sky or near the ground. Thus, by definition, if there are more stimuli available, there can be more reports (whether aircraft or, as some contend, extraterrestrial objects).

2) **Opportunity to observe.** People inside buildings have limited opportunities to observe the environment. This is more the case, all things being equal, for those in an indoors work environment compared to being home where there are chances to take a walk, sit outside, etc.

3) **Attention to environment.** To see something a person must be paying attention to their surroundings (although some UFOs are reported to be so bright or large that they draw attention to themselves). Anything that changes this attention could affect the number of reports.

4) **Willingness to report.** Most people who see a UFO do not report the experience. One key reason is motivation or willingness, which can be affected by concern for how one will be viewed, or whether there will be unexpected consequences of reporting. Conversely, seeing a UFO can be exciting, and people often wish to tell others about their experience.

5) **Time to make a report.** People are busy and have limited time for unplanned activities. Making a report takes time and effort, including finding a reporting organization/site, completing the sighting form, and then perhaps having to email/speak with an investigator. This can be a significant deterrent.

The pandemic led to increased time at home for a large fraction of the population. Although many at home continued working or attending school, the home environment was not as restrictive as being at work, and so one could naturally hypothesize that UFO reports increased commensurate with the proportion of the population at home, compared to previous years. The pandemic did re-

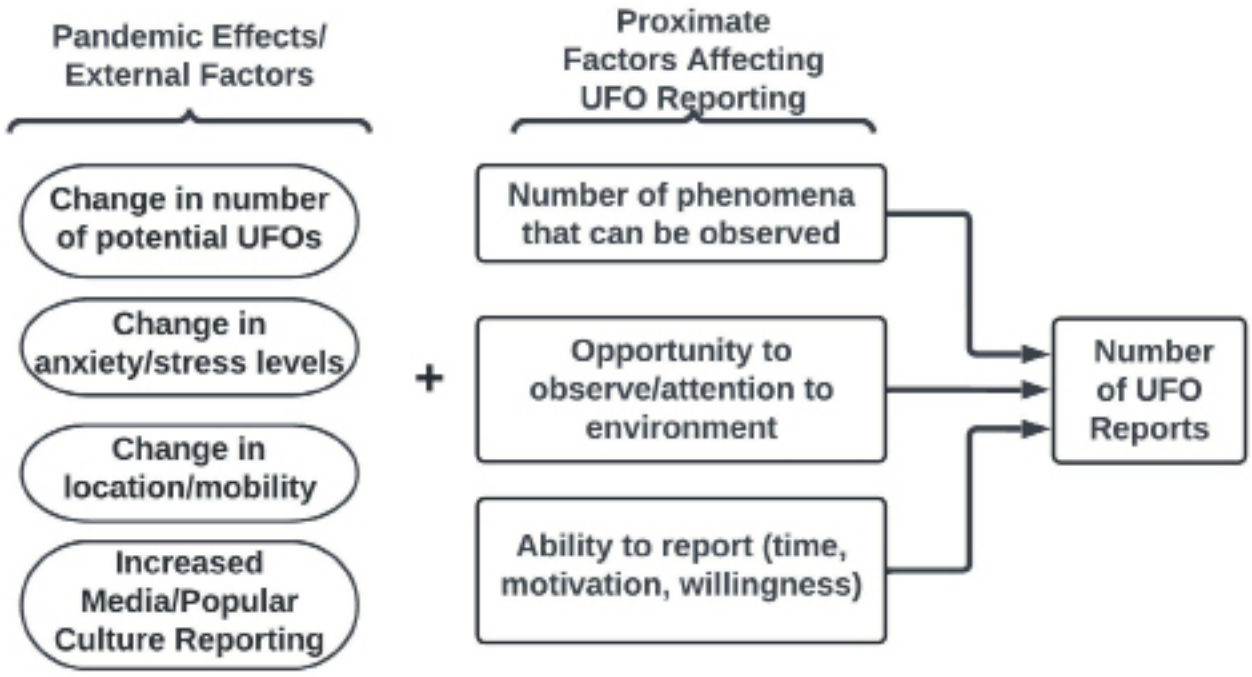

Figure 4. UFO reporting dynamics. Model of physical, social, psychological, and pandemic-related factors that can influence UFO reporting.

quire some people to care for loved ones, it complicated shopping and other daily activities, and so might have decreased the time available to make a report. Nevertheless, given the many anecdotal reports about increased free time (e.g., catching up on projects, binge-watching television series, etc.) (Buga, 2021; Gray, 2020), we expect the overall effect of this factor would be a potential increase in reports.

Past research on UFO waves has suggested that their fundamental cause could be social factors, such as societal crises (the launch of Sputnik in the fall of 1957), economic distress (the oil shocks of the early 1970s), or general anxiety and frustration (the Vietnam War in the 1960s). These are presumed to cause people to enter a state of heightened concern and anxiety and be more watchful of events and, possibly, the local environment. The pandemic caused increased stress for almost everyone (Allen et al., 2022; Knox et al., 2022; Salari et al., 2020), and thus, based on these conjectures, could be presumed to indirectly cause more reports because of increased stress as well as attention to one's environment (Billig, 1982; Escolà-Gascón et al., 2020; Kottmeyer, 1995; Smelser, 1963; Vagues, 1976)

It has been theorized that past UFO waves have been triggered by excessive media attention on UFO reports, which then encourages other witnesses to come forward, in a reverse process to the spiral of silence theory developed by Noelle-Neumann (1974). UFOs have received more positive publicity recently because of favorable coverage by mainstream media, after a story in *The New York Times* on December 4, 2017 (Cooper, 2017). However, UFO reports themselves were not highlighted in the news during the pandemic (as compared to the noted speculation about the number of reports), and so we suggest this factor had a minor role to play in changing the level of reports by varying the willingness to report.

The number of potential UFOs might seem impossible to estimate, but there is another space-based, but human-caused, source which complicates investigating the variation in UFO reporting. The company SpaceX, founded by entrepreneur Elon Musk, has an ambitious program to launch thousands of small satellites to provide internet service across the Earth, especially to areas without reliable access. The constellation of satellites is named Starlink, and by the end of 2021 more than 1700 had been launched, typically in groups of 60 at a time (Wikipedia, 2022). These satellites in the period after launch form a 'train' in orbit, following one after the other, and are visible with the naked eye. While they have often been reported and photographed, and the media have covered the sightings and written about the project, many people remained unfamiliar with the Starlink project Thus, an observation of multiple Starlink satellites moving together (as compared

to a single satellite traversing the sky), would seem highly unusual.

The first test satellite constellation of Starlink was launched in May 2019, and the first operational launch was in November 2019, with launch frequency increasing in early 2020. This coincides closely with the beginning of the pandemic restrictions in the United States in mid-March 2020. UFO reporting sites began receiving reports of 'UFOs' that were clearly caused by Starlink in 2019 after the first launches; as a consequence, organizations attempted to alert witnesses, and still do until today, by providing information about Starlink on reporting pages on their websites , though this had a limited effect. Thus, any consideration of UFO reporting dynamics in 2019–2020 must consider Starlink satellites.

In summary, the UFO reporting proximate factors, and pandemic effects or external factors that influence them, generally suggest that reports should have increased during the pandemic. It is impossible to accurately estimate the magnitude of an increase, but our primary hypothesis is that UFO reporting will increase shortly after the pandemic shutdowns occurred and last for many months thereafter. We expect that over time these effects could diminish, so we restrict the analysis to calendar year 2020 and the immediately preceding years for comparison.

DATA AND METHODS

The three sources of data included in this analysis were UFO reports; pandemic-related data such as mobility, time at home, and SARS-CoV-2 cases and deaths (Coronavirus, 2021); and Starlink launch dates and satellite configurations.

UFO Reports

Two sources of UFO reports were used for this research. The National UFO Reporting Center (NUFORC) is an online reporting center that has recorded reports at its website since the mid-1990s. It includes sightings before that date because of retrospective reporting. Basic report information is freely available to the public. The Mutual UFO Network (MUFON) is the largest civilian US group that investigates UFO sightings (www.mufon.com). Reports can be made at its website and searches can be done for reports by various characteristics, although full access is only available to MUFON members.

Complete NUFORC data were downloaded on February 15, 2021; MUFON data were provided on March 1, 2021, for the years 2018, 2019, and 2020. We note that, when people choose to report a UFO sighting, they typically do so within a few days of the event (Antonio et al., 2022), however this is not always the case; due to these reporting delays, some sightings from the 2018–2020 period will be reported after the data were accessed, but the number will be small compared to the total for each database of about 5,000 reports per year. Only reports from the United States are used in this analysis.

Sighting characteristics included in the MUFON data include: submission date, sighting date and time, city, county, state, shape, sighting description, and case disposition. The disposition (cause or source of the report) is coded by MUFON investigators from a review of the report details, witness interviews, and other investigation into the sighting (e.g., flight radar to show aircraft in the area at the time). Sighting characteristics included in the NUFORC data include: submission date, sighting date and time, city, state, shape, duration, and sighting description. NUFORC is not an investigative organization and does not classify the possible source for a report, although possible hoax cases are noted.

We are interested in the current analysis with the simple fact that a UFO report was made, not how a case was classified by a UFO organization (with one exception as described below). Reports without a sighting description were not included because, as we explain below, all reports had to be coded as caused by the Starlink satellite constellation, or not. Blank reports made up ~0.2% of reports in the NUFORC database and 0.3% of reports in the MUFON database. Raw UFO report data required extensive cleaning: 1) When examining reports at the county level, any report for which the county could not be identified, often due to typographical errors upon report entry, was removed; 2) Duplicate entries were removed; 3) Only reports that originated from the United States were considered; 4) 'Hoaxes' were removed—both NUFORC and MUFON have procedures to indicate reports that are clearly made in jest. Additionally, for the NUFORC database only, beginning in the middle of 2018, magnetic anomalies detected by the Multiple Anomaly Detection and Automatic Recording project (MADAR; https://madar.site/madar/more.html) were added to the NUFORC database, but these are not UFO reports as such, so they were removed before analysis. The inclusion of MADAR anomalies in the NUFORC data means that the use of unfiltered NUFORC data for research, a common practice by media organizations and others, will selectively bias upward UFO reporting statistics.

Pandemic-Related Data

To quantify the effect of pandemic-induced behavioral changes (e.g., lockdowns, work-from-home, bar/restaurant closures, etc.), we utilized the Google Community Mobility Report (https://www.google.com/covid19/mobil-

ity) which provides a metric of how much time people who use Google Maps spent at various places, including home, work, public transit, retail, and social locations, compared to a baseline of data collected prior to the first detection of SARS-CoV-2 in the United States. As this data is highly inter-correlated, we define a single metric as to the extent that a region followed social-distancing related pandemic mitigation measures by summing the time spent at home (relative to the baseline) for each state, noting that this metric was essentially the inverse of time spent at work and leisure (retail, restaurants, etc.). These data were aggregated at the state level by necessity as data privacy considerations precluded reporting at a finer resolution for counties that are less populated. The number of new SARS-CoV-2 cases and deaths are a direct measure of pandemic/disease severity. These measures are used as proxies for anxiety and stress in the population.

Starlink Launches

Starlink launches by SpaceX began with a test of two satellites on February 22, 2018, with the first test of 60 satellites on May 24, 2019, and the first operational launch of 60 satellites on November 11, 2019 (Mann, 2022). The Wikipedia page for Starlink includes a full spreadsheet of all launch information and these data were used for launch dates and other related information, specifically which satellite launches were launched with a sunshade to limit optical reflection, discussed below. Starlink satellites are distinctive because in the period after launch—a few days to weeks—the 60 satellites often form a long train that moves swiftly across the sky, generally from west to east. Starlink satellites do not have their own illumination and are visible because they reflect the Sun's light from various components, such as the antenna. Many Starlink satellites are above a limiting visual magnitude, depending on location, time of day, and sky brightness, and so easily observed by individuals with no visual aid (Boley et al., 2021).

As criticisms of Starlink's interference with astronomical observations increased, Starlink took several measures to reduce satellite brightness, with the key alteration being the addition of a sunshade (Visorsat) to shade the area causing illumination from reflected sunlight (Mallama, 2021; Mallama, 2021). Beginning with the August 7, 2020, launch, all satellites were equipped with the sunshade. This has reduced the apparent brightness of a typical satellite by approximately 50% (Mallama, 2021). We investigate whether this had a separate effect on Starlink-caused UFO reporting.

Coding UFO Reports for Starlink

UFO witness sighting descriptions range from extremely terse ("lighted orbs") to extremely verbose, running to hundreds of words. Generally, NUFORC descriptions are somewhat lengthier than MUFON descriptions because of how the reporting process is structured. Some reports have no description and so could not be coded.

Reports caused by Starlink are generally easily identified. Here are representative examples from the two databases: MUFON ("at least 50 bright lights following each other about 20 seconds apart."); NUFORC ("About 20–30 lights in total appeared in the night sky, traveling in the same trajectory. First one appeared, traveled 4 finger distance then the second one appears where the first one originated and the line continued in that order, speed and distance.").

Two of the authors reviewed the MUFON (LM) and NUFORC (MR) database case descriptions, beginning with the first launch of a Starlink satellite constellation (May 24, 2019). Cases were coded into these three categories: Not Starlink, Starlink, or ambiguous. Coding rules are included in the supporting document (Cockrell et al. Supporting Material). Essentially, at least 3 lights (not objects) had to move in a straight line, at about the pace of a typical satellite (more than a few seconds across the sky, but not many minutes), and during darkness, as Starlink satellites are not bright enough to be viewed with the naked eye in sunlight or even twilight. Location was also used to make a determination because several Starlink reports often came from the same state at the same date and time, and so a report that might be more difficult to code could be assigned to Starlink based on similar and nearby sightings.

To calculate inter-rater agreement, we extracted 200 reports each from the MUFON and NUFORC databases from late February to early March 2020, a period during which Starlink satellites were visible. Each rater coded reports from the database he or she had not previously reviewed, and then the Fleiss kappa statistic was calculated (Fleiss, 1971). Kappa was 0.89 with a 95% confidence interval from 0.79 to 0.99. A kappa of this magnitude is viewed as high and quite adequate to support the reliability of, in this instance, our UFO report coding for Starlink observations. Coding rules were validated by reviewing a subset of reports from late 2018 when no Starlink satellites had been launched; we identified no reports as Starlink in this set, further supporting the reliability of the coding.

Statistical Analysis

To examine the potential causal effect of the pandemic on UFO reporting, we first compared the number of reports by year with a one-sample chi square test to determine whether reports did increase. We then compared the weekly SARS-CoV-2 cases and deaths to the report differential between 2019 (when there was no pandemic) and 2020 on a per-capita and raw basis, aggregated geographically by state, using a standard Pearson correlation (Benesty et al., 2009). To examine the effects of pandemic-mitigation measures, colloquially referred to as the "lockdown," we created a single metric to describe the magnitude of the lockdown response. This metric was developed by summing the weekly (state-level) measurements for additional time spent at home; states that, on average, spent more time at home (compared to a control baseline) had a greater magnitude of the lockdown response. We compared the ranks of differential UFO reporting per state and lockdown response per state using the standard Spearman correlation (Wissler, 1905). To examine the effect of the lockdown on UFO reporting at a national level, we compared the time series of UFO reports (with Starlink sightings, and with Starlink sightings filtered out), to the time series of the CMR 'time-spent-at-home' measurement using a Pearson cross-correlation. We calculated direct correlations and then differenced correlations to remove trend in the series. Finally, we compared the number of reports by year with Starlink reports filtered out. All analyses are done separately for the MUFON and NUFORC databases. MATLAB software was used for analyses and figures.

RESULTS

The impetus for this work was the reporting (Jett, 2021; Nir, 2021) that UFO reports were spiking due to the SARS-CoV-2 pandemic. In Table 1 we compare the number of reports in 2018, 2019, and 2020 for NUFORC and MUFON. As noted earlier, reports to NUFORC had already been increasing in 2019, but this was not true for MUFON. The increase of more than 600 reports to NUFORC, and almost 600 reports to MUFON, in 2020 compared to 2019, was significant for each database ($p < 0.001$). Thus, while not a classic UFO wave, UFO reports did increase in 2020.

TABLE 1. Total UFO Reports by Year, Separately for NUFORC and MUFON

UFO Reporting Site	2018	2019	2020	P-value*
NUFORC	3058	5262	5882	<0.001
MUFON	4315	3929	4503	<0.001

*P-values for a comparison of sum of reports in 2019 to 2020, using a one-sample chi square test.

We next investigate factors that could be related to this change in reporting. In Figure 5, we compare the weekly UFO reports submitted to NUFORC (upper panel), and MUFON (lower panel), with new weekly SARS-CoV-2 cases (dashed line) and new weekly deaths that were attributed to SARS-CoV-2 (grey line). Data are normalized to a range from 0 to 1 for each series. While there is a spike in UFO reports that coincides with the onset of the pandemic, these time series are generally uncorrelated (see Table 2).

To examine the effects of pandemic-mitigation measures, colloquially referred to as the "lockdown," we utilized CMR data provided by Google to examine if additional time spent at home influenced UFO reporting, shown in Figure 6, and again no meaningful correlation was found. UFO report data are normalized to a range from 0 to 1; CMR data are normalized to data from the previous year and so can have values below 0 or above 1. We also ranked each state by a measure of their aggregate pandemic mitigation, which was calculated by summing the weekly measurements from the CMR for 2020 and compared this to the difference in UFO reports from 2019 to 2020 by total reports (Figure 7, left panel), and per-capita reports (Figure 7, right panel). There is no association between the lockdown response and raw report difference or per capita report difference (Pearson correlations of 0.22. and 0.10, respectively; $p = 0.12$ and 0.48, respectively). See Table 2.

Upon further examination of the data, it became apparent that the increase in UFO reports was due to the launch of Starlink satellites, which began in 2019, and which introduced a novel visual phenomenon.

We hypothesize that the unique and unparalleled (at the time) appearance of these sightings provided a significant motivation to file a UFO report. In Figure 8, we compare the time series of all UFO reports (black lines) with Starlink launches before (dotted lines) and after (dot-dashed lines) the addition of a sunshade to the satellites to prevent some amount of interference with astronomical observations, for NUFORC reports (upper panel) and MUFON reports (lower panel). In Figure 9, we examine only the reports that are clearly reports of Starlink satellites, noting the excellent concordance between NUFORC and MUFON reports. The association between launch dates and an increase in Starlink reports is evident, and the number of reports that are attributable to Starlink satellites is reduced by approximately a factor of 10 after the sunshade is added to Starlink satellites. While the sunshade does not render the satellites completely invisible, it significantly reduces the number of UFO reports that are directly attributable to Starlink.

In Table 2 we quantify the relationship between lockdown and pandemic health measures and the UFO report data with a set of correlations between a) case differences between 2019 and 2020, both unadjusted and per capita,

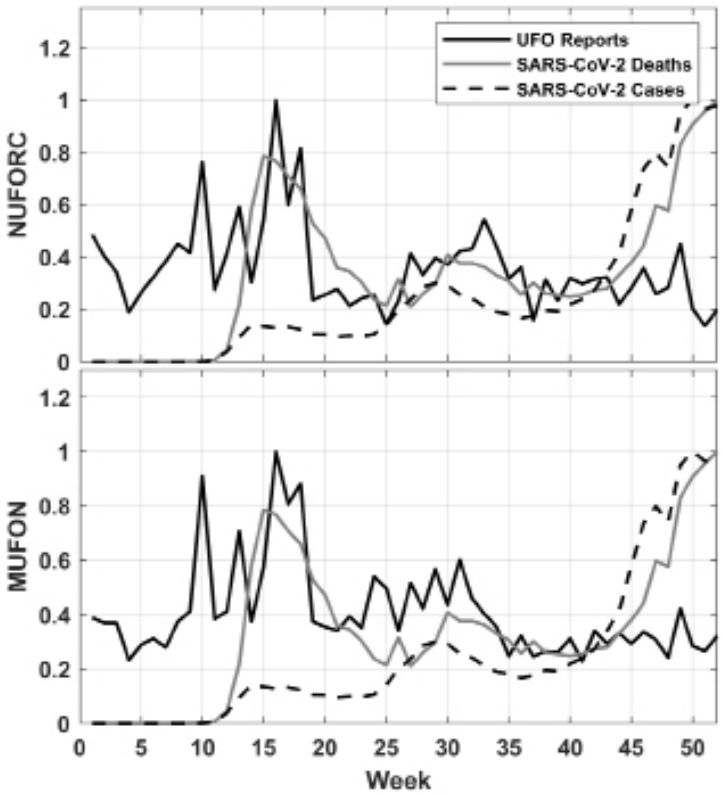

Figure 5. Comparison of UFO report counts with measures of the SARS-CoV-2 pandemic. (Upper panel): The weekly count of UFO reports submitted to NUFORC (black line) is compared with the weekly count of new SARS-CoV-2 cases (dashed line) and deaths (grey line). (Lower panel): We compare the weekly count of UFO reports submitted to MUFON (black line) with new SARS-CoV-2 cases and deaths, line types as above. All metrics have been normalized by dividing the series by its maximum value, resulting in a measure that can vary from 0 (indicating a true zero) to 1 (indicating maximum value in that time period).

TABLE 2. Pearson Correlations between Total UFO Reports and Pandemic Statistics (cases, deaths, excess time spent at home)

	NUFORC		MUFON	
Differences Aggregated by State				
Starlink Filtered	**Statistic**	**P-Value**	**Statistic**	**P-Value**
UFO Report Difference (2020–2019) per capita vs. Lockdown Response	–0.01	0.97	–0.09	0.53
UFO Report Difference (2020–2019) per capita vs. SARS-CoV-2 Cases per capita	0.10	0.49	0.24	0.08
UFO Report Difference (2020–2019) per capita vs. SARS-CoV-2 deaths per capita	–0.07	0.60	0.08	0.56
UFO Report Difference (2020–2019) vs. Lockdown Response	–0.06	0.69	0.12	0.40
UFO Report Difference (2020–2019) vs. Total SARS-CoV-2 Cases	0.19	0.18	0.06	0.67
UFO Report Difference (2020–2019) vs. Total SARS-CoV-2 Deaths	0.06	0.67	0.02	0.89
With Starlink				
UFO Report Difference (2020–2019) per capita vs. Lockdown Response	0.07	0.65	–0.04	0.76
UFO Report Difference (2020–019) per capita vs. SARS-CoV-2 Cases per capita	0.17	0.25	0.29	0.04
UFO Report Difference (2020–2019) per capita vs. SARS-CoV-2 deaths per capita	–0.06	0.68	0.09	0.54
UFO Report Difference (2020–2019) vs. Lockdown Response	0.18	0.21	0.23	0.10
UFO Report Difference (2020–2019) vs. Total SARS-CoV-2 Cases	0.23	0.11	0.05	0.71
UFO Report Difference (2020–2019) vs. Total SARS-CoV-2 Deaths	0.05	0.71	0.01	0.97

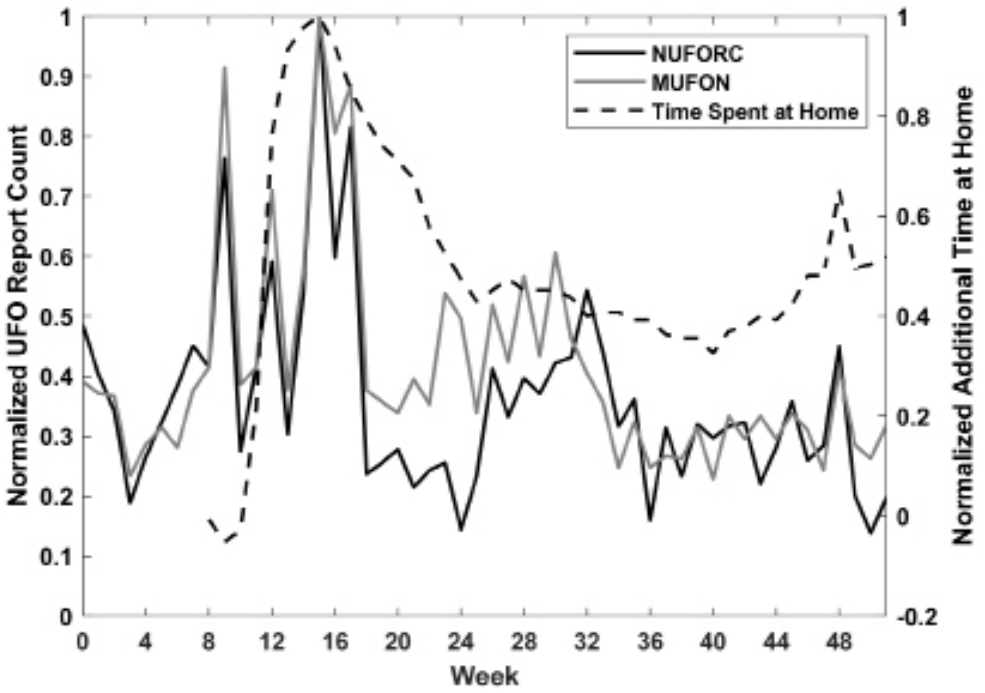

Figure 6. Comparison of UFO report counts with additional time spent at home. The weekly count of UFO reports submitted to NUFORC are shown in black; the weekly count of UFO reports submitted to MUFON is shown in grey; the additional time spent at home due to pandemic mitigation efforts, compared to a 6-week baseline measurement at the start of the year, is shown with the dashed line. UFO reports have been normalized by dividing the series by its maximum value, resulting in a measure that can vary from 0 (indicating a true zero) to 1 (indicating maximum value in that time period). CMR data are normalized to data from the previous year and so can have values below 0 or above 1. While the peak number of reports submitted to NUFORC and MUFON coincides with maximum additional time spent at home, these time series are generally uncorrelated in most of 2020.

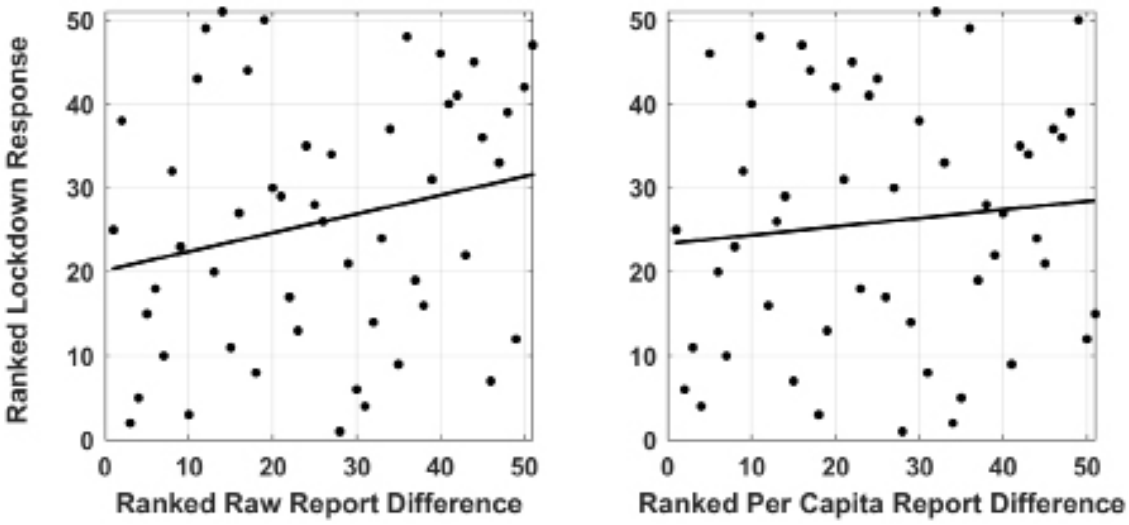

Figure 7. Rank of lockdown response compared with rank increase in UFO reports from 2019 to 2020. (Left panel) We compare the rank of lockdown response with the rank of increase in UFO reporting for each of the 50 United States and the District of Columbia. The rank of the lockdown response is defined such that the state which spent the most additional time at home (see Figure 6) has the highest rank. (Right panel) Depicts the same comparison, however UFO reports are now normalized on a per-capita basis (per state). Additional time spent at home was not correlated with an increase in UFO reporting on a state-by-state basis.

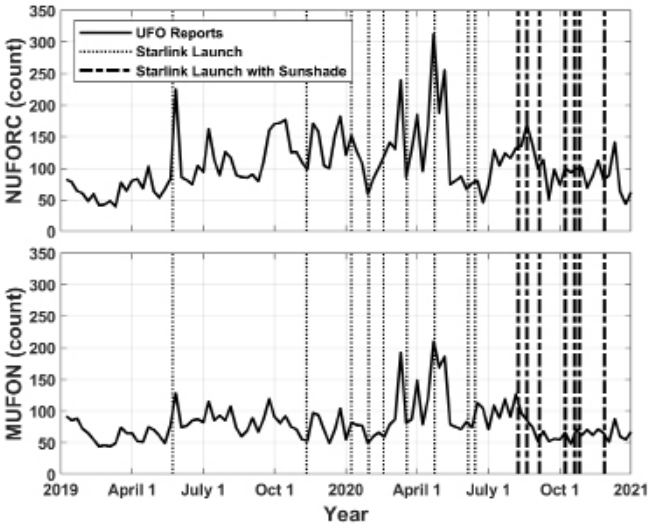

Figure 8. Weekly UFO reports annotated with Starlink launches. (Upper panel): Weekly count of UFO reports submitted to NUFORC is shown with a solid line; Starlink satellite launches are indicated with a vertical dotted or dashed line. The dashed vertical line indicates the satellites were launched with a sunshade to minimize reflected light (visibility). (Lower panel): Similar comparison for UFO reports submitted to MUFON, line style and configured as above.

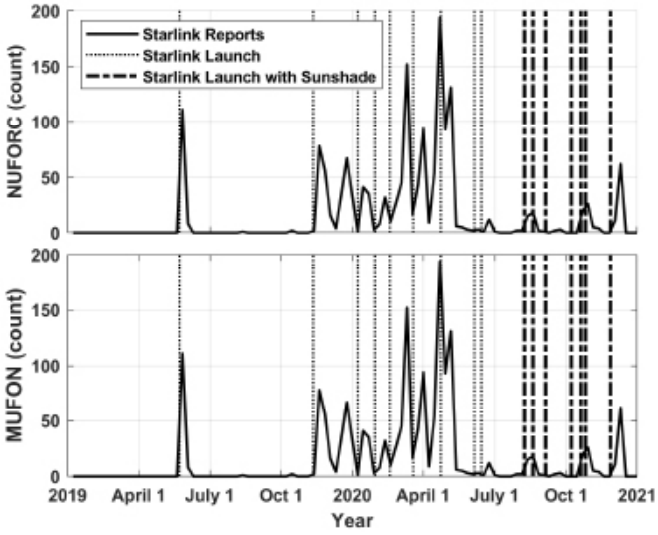

Figure 9. Weekly UFO reports identified as Starlink satellites. To highlight the effect of Starlink satellite launches on UFO reporting, we compare only the reports that are clearly Starlink satellites submitted to NUFORC (upper panel) and MUFON (lower panel). Starlink satellite launches are indicated with a vertical dotted or dashed line. The dashed vertical line indicates the satellites were launched with a sunshade to minimize reflected light (visibility). We note that the addition of the sunshade significantly decreased the number of Starlink satellites that are reported as UFOs.

and lockdown and health measures (aggregated by state); and b) time series of weekly UFO reports with lockdown and health measures across all fifty states. In both sets, correlations are presented including or excluding Starlink reports. Time series correlations, shown in Table 3, are calculated with either non-differenced or differenced values for comparison, with the latter creating stationary series. We expect these correlations to be positive if pandemic-related effects lead to more UFO reports, and in general correlations are above 0. However, most are small in size, between 0.0 and 0.3 in absolute value, and very few are significant at the conventional $p < 0.05$ level; further, we have not adjusted for the number of correlations, which would increase p values, or alternatively, use a lower p for significance. The highest correlation is –0.33 between all reports, including Starlink, and SARS-CoV-2 cases ($p = 0.03$), but this is moderate, at best, and importantly, is in the opposite direction of what is expected from theory, so that higher numbers of cases are associated with fewer reports.

For a visual comparison of pandemic-related measures to the report data with Starlink sightings removed, Figure 10 compares the weekly UFO reports submitted to NUFORC (upper panel), and MUFON (lower panel), with new weekly SARS-CoV-2 cases (dashed line) and new weekly deaths that were attributed to SARS-CoV-2 (grey line). Data are normalized to a range from 0 to 1 for each series. These time series remain generally uncorrelated. See Table 2. Figure 11 then displays the relationship between the Google CMR data and the UFO reports for NUFORC and MUFON, with Starlink reports removed. Again, the UFO report series are generally not correlated with the strength of the lockdown response.

We conclude by returning to the question that motivated this analysis: Did UFO reports increase during the pandemic? Table 4 presents the number of UFO reports without Starlink, and Starlink reports, with ambiguous reports that could not be coded removed, by year and organization. Since the pandemic did not begin in earnest until March 2020, we present results for the full year and then only the March through December period. There were a large number of Starlink reports even in 2019; in 2020 more than 20% (1194/5855) of reports to NUFORC were from Starlink, with a slightly higher percentage from

TABLE 3. Time-series analysis between total UFO reports and pandemic statistics (cases, deaths, excess time spent at home)

	NUFORC		MUFON	
Time Series	**Statistic**	**P-Value**	**Statistic**	**P-Value**
Starlink Filtered, Not Differenced				
All Reports vs Strength of Lockdown (National)	−0.05	0.75	0.05	0.75
All Reports vs Weekly SARS-CoV-2 Cases (National)	−0.26	0.08	−0.25	0.10
All Reports vs Weekly SARS-CoV-2 Deaths (National)	−0.14	0.35	−0.02	0.88
Starlink Filtered, Differenced, Confirmed Stationary ($p < 0.001$)				
All Reports Sightings vs Strength of Lockdown (National)	0.17	0.27	−0.22	0.15
All Reports Sightings vs Weekly SARS-CoV-2 Cases (National)	0.15	0.34	0.13	0.39
All Reports Sightings vs Weekly SARS-CoV-2 Deaths (National)	0.00	0.99	−0.02	0.89
With Starlink , Not Differenced				
All Reports vs Strength of Lockdown (National)	0.19	0.22	0.30	0.05
All Reports vs Weekly SARS-CoV-2 Cases (National)	−0.31	0.04	−0.33	0.03
All Reports vs Weekly SARS-CoV-2 Deaths (National)	0.03	0.83	0.09	0.57
With Starlink, Differenced, Confirmed Stationary ($p<0.001$)				
All Reports vs Strength of Lockdown (National)	0.00	1.00	−0.13	0.38
All Reports vs Weekly SARS-CoV-2 Cases (National)	0.10	0.49	0.09	0.57
All Reports vs Weekly SARS-CoV-2 Deaths (National)	0.05	0.073	0.01	0.95

TABLE 4. UFO reports and Starlink reports 2018–2020, for NUFORC and MUFON, by the complete year and March–December period. All reports exclude those that were too ambiguous to code as Starlink.

	NUFORC		MUFON	
Year	**UFO Reports without Starlink**	**Starlink Reports**	**UFO Reports without Starlink**	**Starlink Reports**
		All Months		
2018	3058	0	4315	0
2019	4837	414	3734	150
2020	4651	1194	3716	663
P Value*	0.056		0.835	
		March through December		
2018	2541	0	3661	0
2019	4349	414	3171	150
2020	3892	1010	3203	604
P Value*	<0.001		0.689	

*P values compare the sum of reports in 2019 to 2020, using a one-sample chi square test.

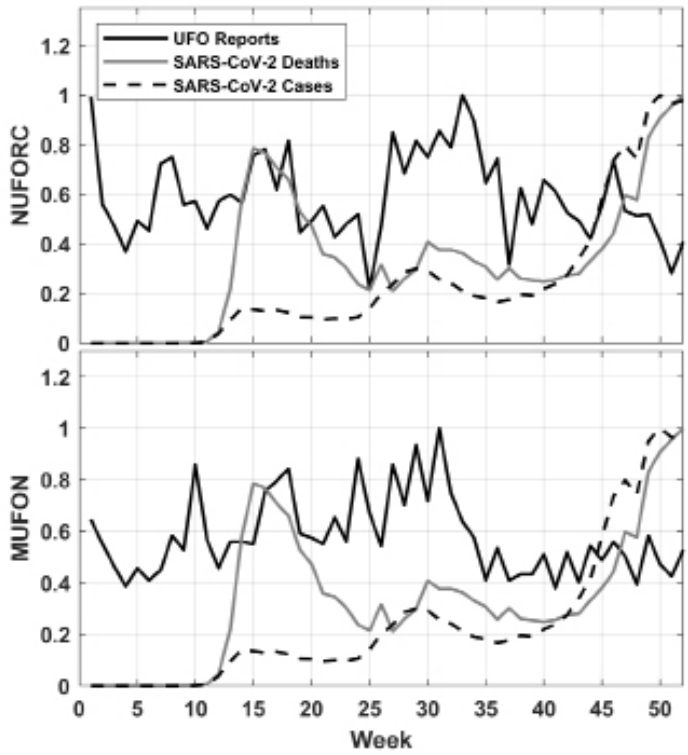

Figure 10. Comparison of UFO report counts with Starlink reports removed with measures of the SARS-CoV-2 pandemic. In parallel to Figure 5, (Upper panel): Weekly count of UFO reports submitted to NUFORC (black line), but with Starlink reports removed, is compared with the weekly count of new SARS-CoV-2 cases (dashed line) and deaths (grey line). (Lower panel): We compare the weekly count of UFO reports submitted to MUFON (black line), with Starlink reports removed, with new SARS-CoV-2 cases and deaths, line style as above. All metrics have been normalized by dividing the series by its maximum value, resulting in a measure that can vary from 0 (indicating a true zero) to 1 (indicating maximum value in that time period).

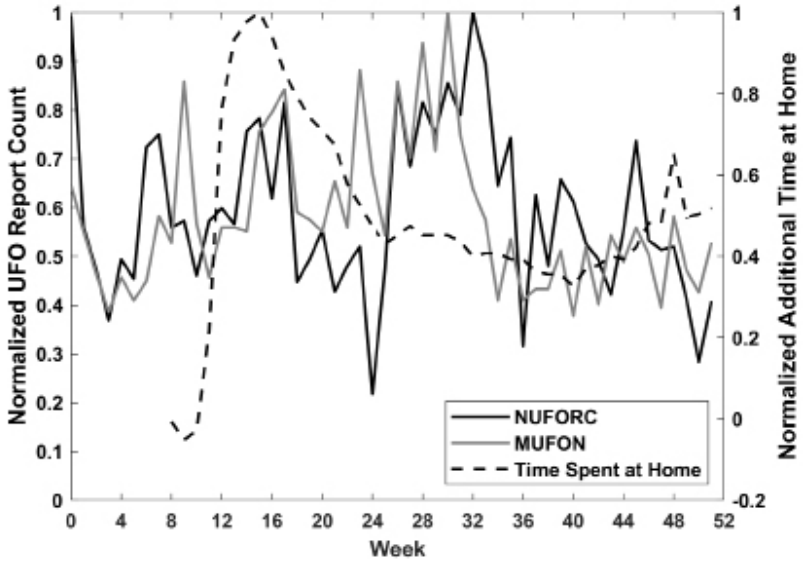

Figure 11. Comparison of UFO report counts with Starlink reports removed with additional time spent at home. The weekly count of UFO reports submitted to NUFORC, but with Starlink reports removed, are shown in black; the weekly count of UFO reports submitted to MUFON, with Starlink reports removed, is shown in grey; the additional time spent at home due to pandemic mitigation efforts, compared to a 6-week baseline measurement at the start of the year, is shown in the dashed line. UFO reports have been normalized by dividing the series by its maximum value, resulting in a measure that can vary from 0 (indicating a true zero) to 1 (indicating maximum value in that time period). CMR data are normalized to data from the previous year and so can have values below 0 or above 1. While the peak number of reports submitted to NUFORC and MUFON coincides with maximum additional time spent at home, these time series are generally uncorrelated in most of 2020.

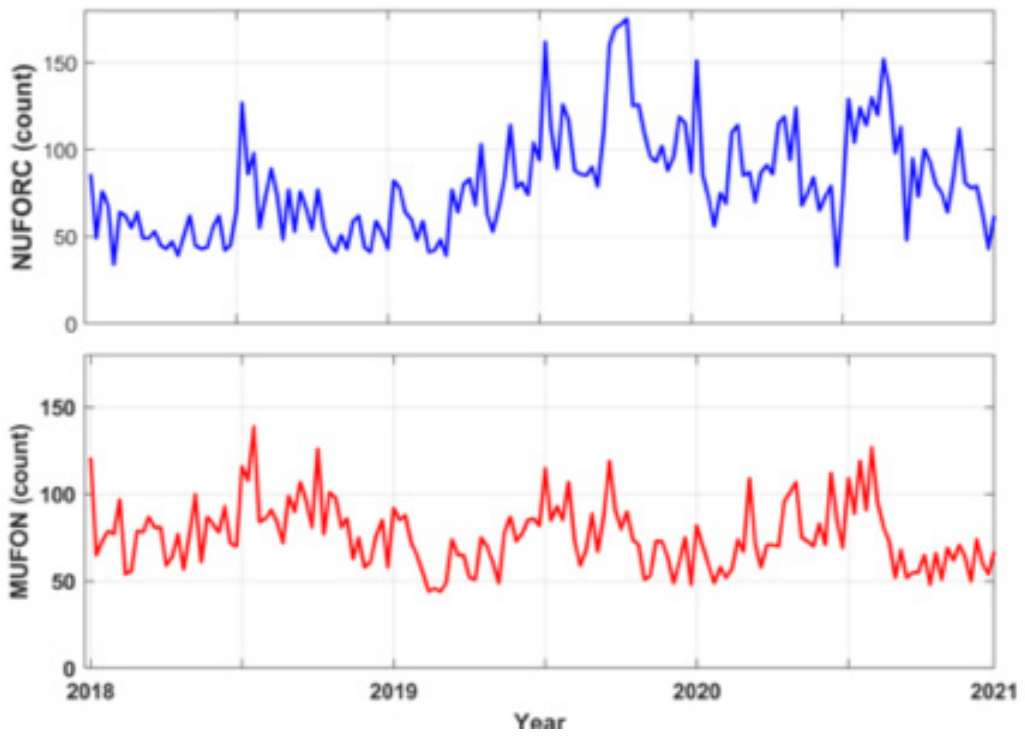

Figure 12. Time series of UFO reports with Starlink sightings removed. The weekly count of submitted UFO reports, with Starlink satellite reports filtered out, to NUFORC (upper panel) and MUFON (lower panel) from 1/1/2018 to 12/31/2020 is displayed. With Starlink sightings removed, there is no increase in UFO reporting in 2020 compared to 2019.

March through December. The percentage of reports to MUFON that were from Starlink was somewhat smaller (15.1% and 15.8%, respectively, in the two periods), but still very substantial. Once Starlink reports are removed, the number of reports in 2020 actually declined at NUFORC (4651 to 4837), although the difference is not significant ($p = 0.056$). The number of reports did decline March through December ($p < 0.01$). MUFON reports in 2020 were almost identical to 2019 in both periods ($p = 0.835$ and $p = 0.689$, respectively). Clearly, there was no increase in UFO reports in 2020 once Starlink sightings are taken into account. Figure 12 displays weekly UFO reports for NUFORC and MUFON for 2018 to 2020, with Starlink reports removed. It is evident that there was no effect of the pandemic on non-Starlink reports.

DISCUSSION

UFO sightings are known to have a number of causes, but making a report about a sighting is a social act. This understanding has led to hypotheses about what social factors can affect the number of reports, and prior research on this topic has found, at best, inconsistent effects of such factors as anxiety, economic problems, and media influences. Our model of UFO reporting suggests that the SARS-CoV-2 pandemic was a natural experiment to investigate whether increased time at home, and generally increased anxiety and stress, was associated with an increase in UFO reports.

At a gross year-over-year level, UFO reports did increase in 2020 in both the NUFORC and MUFON databases. Our analysis of the correlation between the difference in the number of reports comparing 2019 to 2020 showed no association with standard measures of the lockdown response, or the number of cases and deaths caused by SARS-CoV-2. The pandemic affected everyone, and most people in the first year of the pandemic followed the news closely about public health, which led most stories with statistics on cases and deaths. The widespread lockdown effects of the pandemic, and the pandemic's medical outcomes, were not correlated with reports.

We also identified a unique new factor in UFO reporting, recognized by UFO organizations but not the public or media. Sightings of Starlink satellites became a substantial fraction of UFO reports beginning in 2019 and increasing rapidly in 2020. These reports support the factor in our model of UFO reporting that posits that an increase in visible phenomena will result in an increased number of reports. As we have noted, Starlink satellites are becoming an increasing hindrance to astronomical research, and they are also an annoying complication for the investigation of

UFO sightings. We coded all reports for Starlink sightings, and once these were removed the number of sightings in 2020 was not greater than in 2019. Also, filtered reports were not correlated with the various measures of the effect of the pandemic.

Although Starlink satellites were reported as UFOs—and perhaps understandably so—this very fact demonstrates that the public does accurately report what they see in the sky, even if they do not understand what they are viewing. Individual witnesses often were uncertain about the number of lights, the speed, or exact direction of a Starlink satellite train, but the essence of the information was observed, and reported. This basic accuracy is also why UFO organizations have long documented that 90–95% of reports can be identified; that would not be true if witnesses were misreporting critical details.

In total, our results do not support the various hypotheses that one or more social factors caused a change in the number of UFO reports. This finding is consistent with the limited past research (Kottmeyer, 1995) which has failed to find even a modest effect. UFO reports remain puzzling in many of their characteristics, extending even to the question of why their number waxes and wanes over time and location. The pandemic was a terrible disruption to normal life across the globe, but our analysis shows no effects on UFO reporting.

IMPLICATIONS AND APPLICATIONS

This study contributes to a long history of research designed to discover plausible associations of UFO reports with external effects or events. The pandemic offered a unique opportunity to do so and also to test hypotheses about what social influences affect the number of UFO reports. We are hopeful that our work will motivate others to continue and expand this type of research. Based on past work, and reasonable conjectures, associations with geophysical, geographic, astronomical, and meteorological data can be explored from the perspective of the physical sciences, while demographic, economic, sociological, and psychological data can be explored from the perspective of the social sciences.

There is evidence that 'spiritual emergency' is associated with paranormal experience, and pandemic-related stress could place people into this state and thus mediate the relationship with a UFO sighting. While we could not test this, it could be another interesting avenue of research (Storm & Goretzki, 2021).

Although for reasons of data quality and availability our study was restricted to reports from the United States, ideally statistical studies should be based on broader sets of UFO reports. This is more feasible as electronic databases of reports become more available.

While we coded reports to determine whether Starlink was the source, we did not further distinguish between identified and unidentified reports for the analysis. It would be potentially useful to use data from MUFON, or other UFO organizations, which thoroughly investigate and classify sightings, to explore how the total set of identified or unidentified reports during the pandemic compare to the immediately preceding years.

ACKNOWLEDGMENTS

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