

RESEARCH ARTICLE

Temporal trends in health worker social media communication during the COVID-19 pandemic

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Abstract

During the COVID-19 pandemic, healthcare professionals are exposed to extreme hazards and workplace stressors. Social media postings by physicians and nurses related to COVID-19 from January 21 to June 1, 2020 were obtained from the Reddit website. Topic modeling via Latent Dirichlet Allocation (LDA) using a machine-learning approach was performed on 1723 documents, each posted in a unique Reddit discussion. We selected the optimal number of topics using a heuristic approach based on examination of the rate of perplexity change (RPC) across LDA models. A two-step multiple linear regression was done to identify differences across time and between nurses versus physicians. Prevalent topics included excessive workload, positive emotional expression and collegial support, anger and frustration, testing positive for COVID-19 and treatment, use of personal protective equipment, impacts on healthcare jobs, disruption of medical procedures, and general healthcare issues. Nurses' posts initially reflected concern about workload, personal danger, safety precautions, and emotional support to their colleagues. Physicians posted initially more often than nurses about technical aspects of the coronavirus disease, medical equipment, and treatment. Differences narrowed over time: nurses increasingly made technical posts, while physicians' posts increasingly were in the personal domain, suggesting a convergence of the professions over time.

KEYWORDS

COVID-19, nurses, physicians, social media, temporal trends

1 | INTRODUCTION

With more than 500 million cases of COVID-19 and more than six million deaths worldwide (<https://covid19.who.int/>), frontline health workers have been exposed to extreme hazards (e.g., viral transmission, insufficient PPE) (Belingheri et al., 2020; De Vitis et al., 2020) and workplace stressors (e.g., medical crises, patients and families separated and in distress, deaths of patients and coworkers, moral dilemmas) (Q. Chen, Liang, et al., 2020; Chersich et al., 2020; El-Hage

et al., 2020; Gold, 2020; Neto et al., 2020). Stressors confronting healthcare workers extend into their personal lives (e.g., fear and guilt regarding the safety of loved ones, isolation in lengthy periods of self-quarantine, stigma and violence from community members, additional responsibility to care for, and school homebound children) (Bayham & Fenichel, 2020; Q. Chen, Liang, et al., 2020; Ornell et al., 2020; Shanafelt et al., 2020). According to surveys (Nissan et al., 2021; Ruiz-Fernandez et al., 2021), and as described by the World Health Organization (WHO) in on-line technical guidance (March 2020,

<https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/health-workers>) frontline healthcare workers caring for patients who have been infected with COVID-19 face life threatening hazards as well as both acute and chronic stressors, as summarized in that WHO technical guidance report.

Health workers are at the frontline of the COVID-19 outbreak response and as such are exposed to hazards that put them at risk of infection. Hazards include pathogen exposure, long working hours, psychological distress, fatigue, occupational burnout, stigma, and physical and psychological violence (p. 1).

As a result, on March 19, 2020 the WHO issued recommendations for frontline worker preparedness and safety ([https://www.who.int/publications-detail/coronavirus-disease-\(covid-19\)-outbreak-rights-roles-and-responsibilities-of-health-workers-including-key-considerations-for-occupational-safety-and-health](https://www.who.int/publications-detail/coronavirus-disease-(covid-19)-outbreak-rights-roles-and-responsibilities-of-health-workers-including-key-considerations-for-occupational-safety-and-health)). Despite those recommendations, frontline workers caring for patients infected with the coronavirus have continued to experience multiple stressors including recurrent and chronic exposure to the virus without consistent or sufficient access to adequate personal protective equipment and personal viral testing. They have had to work long hours under high stress without breaks, insufficient accommodation in the case of personal illness, and potential loss of employment when exercising their right to remove themselves or make formal requests when confronted by life threatening conditions.

Social media trends over time offer a unique and ecologically valid source for tracking healthcare professionals' self-reported experiences in crises such as the first months of the COVID-19 pandemic. A study using social media tracked temporal trends in the COVID-19 pandemic to identify qualitative themes (e.g., uncertainty, need for protection) in a region of China during the first months of the pandemic (Li et al., 2020), but no such study has been done with healthcare professionals. An exploratory study therefore was done to determine whether patterns or trends could be identified in the social media postings by physicians and nurses related to the COVID-19 pandemic at its outset (i.e., from January 21 to June 1, 2020).

Healthcare professionals caring for patients with COVID-19 at the outset of the pandemic were exposed to psychologically traumatic (H. Chen, Wang, et al., 2020) threats to their lives, the lives of their coworkers and patients, and the health and lives of their families (Gavin et al., 2020; Ornell et al., 2020; Sim, 2020; Tsamakidis et al., 2020; Zhan et al., 2020). In addition, frontline professionals were confronted by the extreme suffering and death of their patients and their coworkers, and thus were at risk for secondary traumatic stress, compassion fatigue, and vicarious trauma (Alharbi et al., 2020; Orru et al., 2021) as well as posttraumatic grief (Bertuccio & Runion, 2020; Hall, 2020) and posttraumatic stress (Dutheil et al., 2020; Zandifar et al., 2020). They also were faced with the extreme distress and grief of patients' family members who were separated from and unable to comfort quarantined, infected loved-ones who were terrified, confused, in pain, or even dying. When surveyed after the fact, many frontline professionals reported experiencing a sense of fear and guilt related to their families, due to the potential for contamination by exposing loved-ones to a possibly lethal viral infection (Mrklas et al., 2020; De Vitis et al., 2020). Healthcare

professionals also may have experienced a sense of moral injury (i.e., distress due to being unable to uphold core personal and professional values, such as making triage decisions that deny lifesaving care to some patients, as well as having to deny loved ones access to dying patients (Adeyemo et al., 2022).

As a result, in the first months of the pandemic, healthcare professionals were found to be at risk of insomnia, anxiety, depression, posttraumatic stress, somatization, and obsessive-compulsive symptoms (J. Z. Huang, Han, et al., 2020; Kang et al., 2020; Lai et al., 2020; Lin et al., 2020; Liu et al., 2020; Zhang et al., 2020). Nurses and female healthcare workers are more likely to report mental health problems than physicians or male healthcare workers (J. Z. Huang, Han, et al., 2020; Kang et al., 2020; Lai et al., 2020; Zhang et al., 2020). When interpreting those findings, it is important to not assume that nursing is synonymous with female gender and physicians with male gender, to avoid gender-based stereotypes. Apart from professional discipline, women are more likely than men to report mental health problems due to a host of cultural, social, and economic adversities and a greater willingness than men to disclose distress (Riecher-Rossler, 2017). However, although women are over-represented among nurses internationally (Boniol et al., 2019), nursing professionals of both genders may be at risk for mental health problems due to their high levels of direct patient and family contact combined with lesser professional authority and autonomy and longer work shifts than physicians (Nissan et al., 2021; Ruiz-Fernandez et al., 2021).

These findings from surveys of healthcare professionals and workers during the first months of the pandemic reveal potential targets for intervention to prevent or mitigate mental health problems and burnout in this critical workforce (Holmes et al., 2020). However, surveys provide status reports only at a single time-point, and are subject to selection and response biases that may lead to either over- or under-estimates of risk and protective factors and mental health outcomes (Bohlken et al., 2020). In contrast, social media (Lee et al., 2020; Ni et al., 2020) provide a potential alternative data source for identifying the impact of the pandemic on COVID-19 frontline healthcare workers (Li et al., 2020). Healthcare professional' spontaneous on-line social media postings and discussions during this critical period of the first months of the COVID-19 pandemic may reveal concerns and reactions that have not been identified previously, as well as potentially corroborating issues and challenges that have been reported. Nurses and physicians work closely together but have distinct roles, training, and professional cultures. Similarities and differences in the content, frequency, and temporal trends of the two professions' social media postings were therefore investigated to better understand the effects of the pandemic on these critical professional communities.

2 | METHODS

2.1 | Setting

Data were derived from postings on the Reddit social media website. Based on search traffic, as of April 2022, Reddit is the sixth most

popular website in the United States (Semrush, 2022), the 20th worldwide (Neufeld, 2022). The Reddit platform enables participants to post messages anonymously within communities defined by shared backgrounds or thematic interests, referred to as *subreddits*, which are monitored by volunteer moderators who also uphold platform policies. Reddit users can become moderators by creating a new *subreddit*, by invitation from an existing Reddit moderator, or by request through the official Reddit Request *subreddit*. Reddit users can engage with other users' comments by upvoting or downvoting posts, ultimately influencing the visibility of posted content. When compared with other platforms like Meta's Facebook or Twitter, Reddit differs in that it is based around communities and provides user with an increased length allowance for posts, comments, and replies. Mostly focused on textual content, Reddit also differs from highly-visual social media platforms such as Meta's Instagram, Snapchat, and TikTok. For the purpose of the present study, textual postings by on-line communities representing physicians and nurses were selected.

2.2 | Sample/data collection

The majority of Reddit traffic comes from the United States (47%), followed by United Kingdom (8%), Canada (7%), and Australia (3%) (Clement, 2022). Based on the number of members belonging to specific Reddit city communities, the top 10 US cities attracting the largest number of users are (in descending order): New York City, Seattle, Los Angeles, Chicago, Austin, Portland, San Francisco, Boston, Houston, and Atlanta. The majority of American Reddit users (70%) are white, 12% are Hispanic, and 7% are black (Todorov, 2022). Internationally, 28.1% of Reddit users, young adults aged 20–29 make up the platform's largest user base, followed by adults aged 30–39 (26.1%), adolescents up to 19 years old (21%), adults 40–49 years old (14.1%), and adults age 50 or more (10.3%) (Dixon, 2021).

Data were collected from a diverse group of Reddit "subreddits" posted by members worldwide. For the purpose of this study, we inspected *subreddits* whose members could be identified as either physicians (*r/medicine*, 313,052 members; *r/residency*, 60,873 members; *r/doctors*, 5517 members), or nurses (*r/nursing*, 152,576 members; *r/StudentNurse*, 54,179 members, *r/nurse*, 42,472 members). The official language for these *subreddits* is English.

To identify discussions related to COVID-19, we searched the *subreddits* using the following keywords: Ncov, COVID, corona, coronavirus, SARS-CoV-2. The search was performed on June 1, 2020, using the R package *RedditExtractoR* (Rivera, 2019). Although many alternative approaches to access Reddit data exist, we chose the *RedditExtractoR* package because it provides an easy-to-use, mostly code-free interface to search Reddit and retrieve user-generated data. Recently, the *RedditExtractoR* package has been instrumental for studies investigating online discourse about diverse health-related topics (e.g., medication use [Garcia et al., 2022; Smith et al., 2021]; suicidal ideation [Mason et al., 2021]; eating disorders, [Nutley, 2021]).

2.3 | Data analyses

2.3.1 | Topic extraction

Topic modeling via Latent Dirichlet Allocation (LDA, Blei et al., 2003; for a review of its application on social media postings, see Chauhan & Shah, 2021) was performed on the body of documents collected (i.e., document corpus). Each document included all comments posted in a unique Reddit discussion. Before training the LDA model, we converted all text to lowercase and removed English "stopwords" (i.e., very frequent words with low topic specificity), punctuation, and numbers. To identify the optimal number of topics, we trained a set of competing LDA models with the following *k* numbers of topics: 25, 50, 75, 100, 125, 150, 175, and 200 topics. Model training and validation was performed using a machine-learning approach: the document corpus was split in a subset including 90% of the documents that was used to train the model, and 10% was used for model validation. The performance of the competing LDA models was compared by computing the perplexity statistic on the validation set; the optimal number of topics was selected using a commonly used heuristic approach based on examination of the rate of perplexity change (RPC, Zhao et al., 2015) across LDA models with increasing number of topics. This approach is based on the analysis of variation of statistical perplexity, which in information theory represents a common measurement providing an evaluation of how a statistical model describes a data set, with lower perplexity typically denoting a better model. More specifically, using the RPC approach, given the sequence of *k* numbers of topics reported above, the number associated with the change-point value of the RPC was chosen as the most appropriate number of topics for the current discussion document corpus. The semantic coherence of emerging topics was also examined visually using word clouds (i.e., visual representations of words associated with a topic), where each word is shown with a font size that is proportional to its' importance to the specific topic (examples of word clouds are shown in Figure 3a–c). Based on the RPC heuristic procedure, and semantic coherence, we selected *k* = 100 as the final number of topics. As a last step, the selected LDA model was applied on all available discussion documents. In doing this, for each discussion document, a set of scores was generated indicating the prevalence (i.e., topic proportion, which refers to how often each topic occurs in the discussion document, ranging from 0.0 to 1.0 which correspond, respectively, to 0% to 100% of the postings in the document) of each specific topic in the discussion document itself. LDA analyses were performed using the Mallet software (McCallum, 2002), version 2.08. Word clouds were generated using the *wordcloud* package in R (Fellows, 2018).

2.3.2 | Examining the prevalence of topics for nurses and physicians over time

As a first step, we examined the overall distribution of emerging topics across discussions by computing the mean topic proportion

score for each topic. We used a bar chart to represent the most prevalent topics across all discussion documents. A two-step multiple linear regression was done using SPSS, version 24 (SPSS, 2016) to identify differences in prevalence for nurses versus physicians, and across time. First, a model with two main effects was estimated using a dummy variable distinguishing professions (nurse = 1; physician = 0), and a continuous variable representing time of posting (i.e., weeks since January 1). Second, the interaction term for profession by time was added to the model.

3 | RESULTS

Analysis was conducted on a total of 75,080 comments posted by 17,033 users in 1723 discussion documents. Of these 1723 discussion documents 52.9% ($n = 912$) were retrieved from nurses' communities, while 47.1% ($n = 811$) were retrieved from physicians' communities. Based on the timestamp of opening posts, time of discussions ranged from January 21, 2020 to June 1, 2020; 0.9% were posted in January, 2.4% in February, 44.8% in March, 35.3% in April, 16.4% in May, and 0.1% in June. Mean discussion document length = 2226.89 words, SD = 4154.84.

3.1 | Prevalence of emerging topics in the overall sample

Figure 1 shows the topics emerging from 1723 COVID-related discussion documents with mean discussion document topic proportion scores ≥ 0.01 , representing about 79.8% of words posted in the discussion document corpus (topic proportions for all extracted topics are reported in supplementary materials). The specific words that were used to define each topic based on verbatim postings are presented in Tables 1–4. For example, two highly prevalent topics (especially amongst nurses) were labeled “positive emotional expression” (t5) and “excessive workload” (t57) based on keywords that included, respectively, “feel good, hope, love, hard, great days” for t5, and “time, work long times, covid, working lot” for t57. Tables 1 and 2 show the topics that were more prevalent among nurses and physicians, respectively. Tables 3 and 4 show the topics that were similarly prevalent for nurses and physicians and that, respectively, the themes either did (Table 3) or did not (Table 4) change in frequency of posting over time.

Figure 1 shows the prevalence (i.e., mean topic proportion) of topics in posts by nurses and physicians related to COVID-19. Problem-focused topics were prevalent. Extreme workload was the

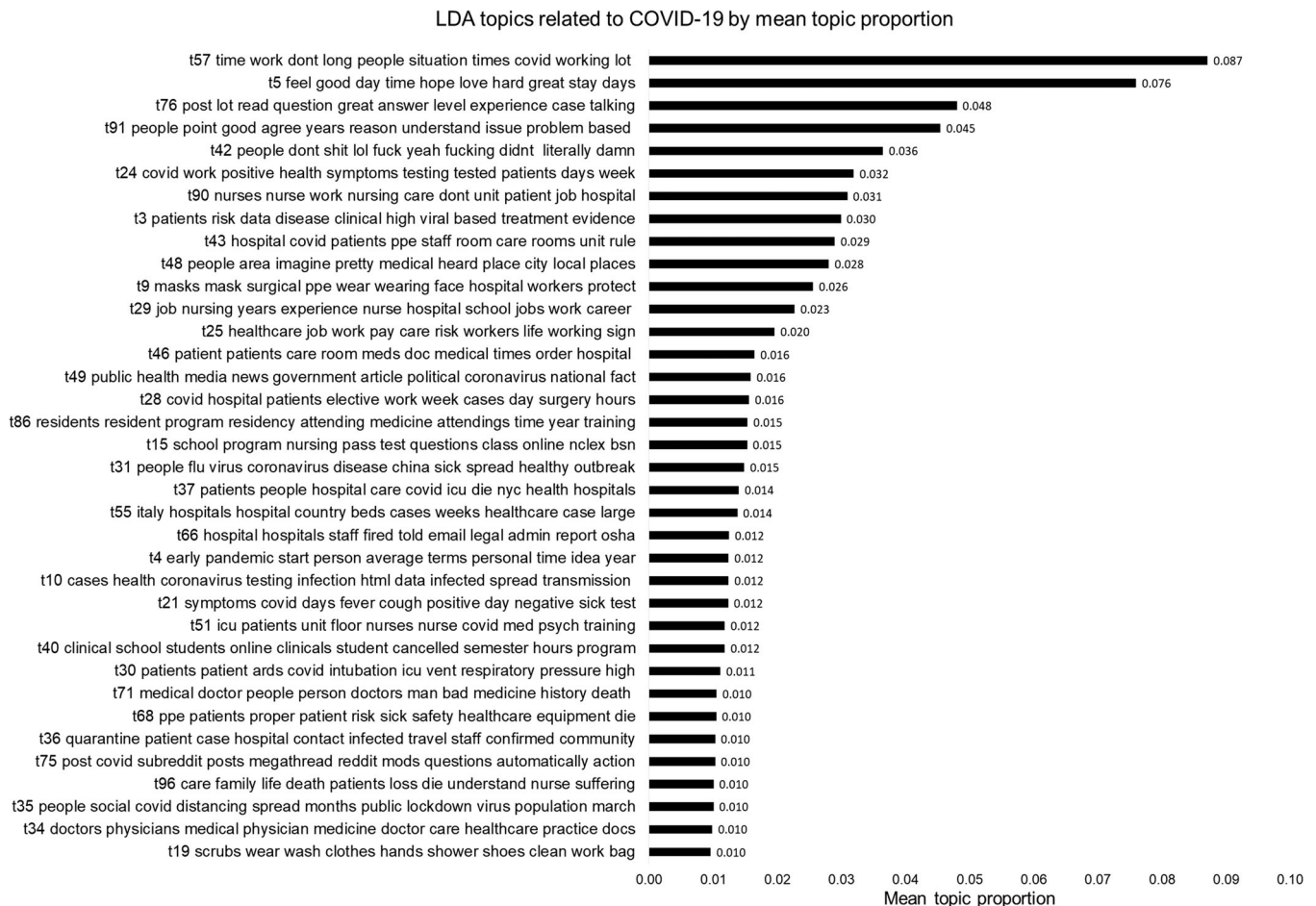


FIGURE 1 LDA topics related to COVID-19 by mean topic proportion. LDA, Latent Dirichlet Allocation.

most prevalent topic (t57; also expressed in t4, t24, t28). Other problem-focused topics included expressions of alienation and anger (t42), personal risk of viral exposure, illness, and quarantine (t3, t4, t10, t21, t25, t31, t46, t68), shortages of facilities and personal protective equipment (t9, t43, t55, t68), risk of being fired for reporting occupational hazards (t66), and concern about patients' severe illness, emergency treatment, and deaths (t30, t37, t68). However, the topic with the second highest prevalence involved expressions of positive emotions (t5; e.g., hope, love, good day), and topics expressing gratitude for online support (t76, t91). A third set of topics related to professional roles, training, and jobs separately in nursing and in medicine (t15, t25, t29, t86, t90), and the healthcare field generally (t49, t48).

3.2 | Prevalence of emerging topics by profession, and time of posting

The 48 topics showing a higher prevalence either among nurses or physicians, but similar temporal trends across professions (i.e., no interaction of profession by time), are shown in Figure 2 for each profession by descending effect-size (i.e., standardized regression effect, controlling for time of posting). Nurses' posting prevalence was higher than physicians on 15 topics (Figure 2, panel a). The top words in these postings referred to nursing practice and training (t51, t90), workload and nightshifts (t52, t57), testing positive for COVID-19 at work (t24), positive emotion exchanges between users

(t5), use of personal protective equipment and safety practices (t19, t68). These topics also reflected discussion about the death of patients (t96), family concerns (t65), risks for pregnant women due to COVID-19 (t65), nursing training (t40), use of moisturizers (t80), local healthcare (t48), and public social media about healthcare workers (t59). Some of these topics showed an increase in prevalence over time, referring to workload (t57), positive online exchanges (t5), patients dying (t96), and positive/negative social media about healthcare workers (t59). Topics referring to use of personal protective equipment (t68) and testing positive for COVID-19 at work (t24) decreased in prevalence over time.

Another 33 topics showed increased prevalence among physicians when compared to nurses (Figure 2, panel b). The majority of these topics focused on COVID-19 disease, clinical trials (t38, t98), mortality rate (t97), diagnosis (t44), viral dynamics (t69, t72, and t92), infection dynamics (t84), testing, (t82), immunity and vaccine (t8), and patients' characteristics (t64). Other topics reflected preoccupation with medical equipment (and lack thereof) (t27, t47), do-not-resuscitate orders (t41), patients' dying (t37, t53), and disruption of elective surgery for non-COVID-19 patients (t28). Other topics included physician practice and training (t13, t39, t71, and t86) and public policies during the COVID-19 pandemic (t2, t4, t35, t14, t49). Physicians also posted more frequently than nurses about online discussion rules (t85), interaction between users (t50, t76), and requests for medical books (t78). There were two topics on which physicians posted more frequently than nurses, but there was an increasing prevalence over time for both professions: stroke and

TABLE 1 Topics prevalent among nurses that had a similar trend over time across professions

Topic	Top words	Profession (β)	Time (β)
t90	Nurses, nurse, work, nursing care, don't, unit, patient, job, hospital	0.502	n.s.
t5	Feel good, day, time, hope, love, hard, great stay, days	0.273	0.114
t57	Time, work, don't, long, people, situation, times, covid, working lot	0.238	0.137
t51	ICU patients, unit, floor, nurses, nurse, covid, med, psych training	0.179	n.s.
t24	Covid, work, positive health, symptoms, testing, tested, patients, days, week	0.177	-0.129
t40	Clinical, school, students, online, clinicals, student, canceled, semester, hours, program	0.150	n.s.
t19	Scrubs, wear, wash, clothes, hands, shower, shoes, clean, work, bag	0.132	n.s.
t52	Shift, food, night, day, eat, work, free hours, pizza, week	0.109	n.s.
t73	Pregnant, baby, women, NICU, risk, pregnancy, weeks, babies, delivery, birth	0.091	n.s.
t65	Kids, family, children, parents, mom, school, wife, husband, child, kid	0.089	n.s.
t80	Good, face, nose, lol, hand, nice, oil, house, cream, color	0.087	n.s.
t48	People, area, imagine, pretty, medical, heard, place, city, local, places	0.081	n.s.
t68	Ppe, patients, proper, patient, risk, sick, safety, healthcare, equipment, die	0.078	-0.081
t96	Care, family, life, death, patients, loss, die, understand, nurse, suffering	0.056	0.070
t59	People, hero, covid, heroes, feel, social media, hate, facebook, share	0.048	0.050

Note: Topics showing a significant positive standardized effect for Profession (Profession: Nurse = 1, Physician = 0) are reported ($p < 0.05$). Profession: Higher positive standardized coefficients indicate higher prevalence among nurses. Time: Positive/negative standardized coefficients indicate increase/decrease in prevalence over time. n.s., not significant.

TABLE 2 Topics prevalent among physicians that had a similar trend over time across professions

Topic	Top words	Profession (β)	Time (β)
t86	Residents, resident, program, residency, attending, medicine, attendings, time, year, training	-0.335	n.s.
t4	Early pandemic, start, person, average, terms, personal time, idea, year	-0.223	n.s.
t49	Public health, media, news, government, article, political, coronavirus, national, fact	-0.162	n.s.
t71	Medical doctor, people, person, doctors, man, bad medicine, history, death	-0.161	n.s.
t85	Removed reddit, comments, comment, rule, medical, subreddit, personal, rules, lead	-0.157	n.s.
t98	hcq study, covid, patients, hydroxychloroquine, studies, data, treatment, evidence, group	-0.155	n.s.
t37	Patients, people, hospital care, covid, icu, die, nyc, health, hospitals	-0.152	-0.075
t76	Post, lot, read, question, great answer, level, experience, case, talking	-0.137	n.s.
t69	Virus, viral, cell, cells, sars, blood, immune, protein, response, hiv	-0.133	n.s.
t39	Clinic, phone, visits, office, primary, urgent, outpatient, visit, care, telehealth	-0.125	n.s.
t8	immunity, vaccine, herd, immune, infected, antibody, population, long, vaccines, antibodies	-0.115	n.s.
t97	Rate, mortality, deaths, death, data, cases, flu, population numbers, higher	-0.106	-0.148
t14	Trump, president, pandemic, administration, cdc, response, political, country, countries, economy	-0.105	n.s.
t72	Subreddit r/medicine, ventilation, ards, workers, heme, binding, hemoglobin, died, orf	-0.096	n.s.
t78	Uptodate free, book, medicine, good rip, access, intern, resource, year	-0.095	n.s.
t28	Covid hospital, patients, elective, work, week, cases, day surgery, hours	-0.090	n.s.
t50	Writing, sharing, hope, days, read, posts, write, work, stay, reading	-0.078	n.s.
t44	Covid scan, mri, diagnosis, glass, suspected, scans, scanner, findings, ground	-0.078	n.s.
t92	Days, rna, weeks, viral, positive, samples, schools, throat, April, swab	-0.076	n.s.
t35	People, social, covid, distancing, spread, months, public, lockdown, virus, population	-0.075	n.s.
t82	Testin,g test, tests, tested, cdc, lab kits, fda, labs, criteria	-0.074	-0.088
t13	Prescribing, prescribe, family, pharmacist, pharmacy, meds, unethical, controlled, prescription, script	-0.073	n.s.
t64	Obese, obesity, ivermectin, concentration, weight, saved, qaly, fat, nbsp, bmi	-0.071	n.s.
t2	Country, visa, Canada, process, green card, immigration, wife, Canadian, countries	-0.070	n.s.
t38	Trial, study, hypothesis, chance, true, null, size, power, difference, sample, statistical	-0.069	n.s.
t27	Exam, stethoscope, tubing, years, neck, littman, stethoscopes, sound, normal, hear	-0.064	n.s.
t33	People, pain, stroke, normal, chest, volume, census, pts, usual, sick	-0.063	.053
t20	Imgur, hearing loss, language, pdf, jpg, calling, racism, criticism, pharmacy	-0.060	-0.055
t53	Death, awkward, march, wondering, bags, York, team, swab, interview, tv/twiv/twiv	-0.057	n.s.
t47	Filters, respirators, respirator, filter, reusable, elastomeric, fit, mask, ebay, cartridges	-0.053	n.s.
t84	cfr, hcov, years, retired, lyme, corona, fever outbreaks, hku, beer	-0.052	n.s.
t41	Code, cpr, dnr, decision, futile, codes, family, team, cases, wishes	-0.052	-0.048
t81	Board, license, step, boards, exam, licensing, certification, school, letter, degree	-0.051	.051

Note: Topics showing a significant negative standardized effect for Profession (Profession: Nurse = 1, Physician = 0) are reported ($p < 0.05$). Profession: Stronger negative standardized coefficients indicate stronger prevalence among physicians. Time: Positive/negative standardized coefficients indicate increase/decrease in prevalence over time. n.s., not significant.

chest pain in COVID-19 patients (t33), and medical and nursing licensing process (t81). Five topics were consistently posted more frequently by physicians than nurses and showed a decrease in posting prevalence over time: patients' treatment and dying in New York (t37), mortality rate of COVID-19 (t97), testing for COVID-19

(t82), discussion about hearing loss (t20), and infection dynamics (t84).

Another 27 topics showed different trends over time for the two professions, as shown in Figure 3a-c. These figures present the association (regression slope) between time (week) and topic

TABLE 3 Topics showing a significant change in prevalence over time with no significant differences in prevalence across professions

Topic	Top words	Time (β)
t23	Health, mental, drug, anxiety, issues, suicide, life, psych, pain, illness	0.101
t22	Police, cops, cop, black, protests, officers, officer, racist, enforcement, white	0.070
t46	Patient, patients, care, room, meds, doc, medical, times, order, hospital	0.051
t36	Quarantine, patient, case, hospital, contact, infected, travel, staff, confirmed, community, isolation	-0.303
t21	Symptoms, covid, days, fever, cough, positive, day, negative, sick, test, mild	-0.051
t18	utm, medium, reddit, source, app, share, covid, ios, iossmf, media	-0.050

Note: Topics showing a significant standardized effect (β) are reported ($p < 0.05$). Time: Positive/negative standardized coefficients indicate increase/decrease in prevalence over time.

TABLE 4 Topics showing no significant difference in prevalence across professions, and across time

Topic	Top words	Mean topic proportion
t25	Healthcare, job, work, pay, care, risk, workers, life, sign, lives	0.019
t66	Hospital, hospitals, staff, fired told, email, legal, admin, report	0.012
t67	Sick, insurance, leave, pto, work, paid, life, policy, comp, disability	0.005
t77	Government, ppe, supplies, draft, supply, companies, military, federal, medical, country	0.004
t70	Wipes, cleaning, room, bleach, effective, light, air, wipe, clean, dry	0.004
t94	Dialysis, labs, practice, blood, monitor, fluid, renal, antibiotics, draw, sepsis	0.003
t93	Video, youtube, videos, com/watch, media, covid, posting, social, post, facebook	0.003
t12	Volunteer, pay, free, travel, paid, week, nyc, insurance, days, volunteers	0.002
t88	Car, aged, restraints, roommate, charges, bank, dementia, assault, rent	0.002
t45	Reddit, message, remindmebot, com/message/compose, subject, reminder, delete, utc, time, reminders	0.002
t87	Tubing, case, pumps, meningitis, csf, diagnosis, heard, interesting, typhoid, seizures	0.002
t56	Sedation, delirium, fentanyl, ketamine, propofol, drip, sleep, pts, dose, brain	0.002
t16	Lab, conspiracy, scientists, Wikipedia, window, theory, years, virology, copper, Russia, funding	0.002
t79	York, arterial, blood, rectal, military, venous, transporting, small, transport	0.002
t60	Conspiracy, vaccine, people, vaccines, gates, government, theories, facebook, anti, vaccination	0.002
t62	ucsf, twitter, fresno, iwar, fbclid, birthday, cetirizine, director, nhs, title	0.001
t89	Allergic, allergy, allergies, word, reaction, pain, list, mucosa, dizzy, benadryl	0.001
t6	Chiropractors, chiropractic, chiropractor, medicine, evidence, profession, zinc based, patients, pain	0.001
t100	Los para, una, las, por, est, pero, ahora, personas, cuando	<0.001

proportion separately for nurses and physicians, with topics presented in numerical order (t1–t26 in Figure 3a; t29–t55 in Figure 3b; t58–98 in Figure 3c). Topics are presented as word clouds, where top words are rendered with increasing font size proportional to their relevance to the specific topic (i.e., word-by-topic frequency count). Three topics with increasing differences in prevalence over time between professions showed increasingly higher prevalence among nurses when compared to physicians: passing nursing schools exams (t15), applying for nursing jobs (t29), and violation of online rules in discussions about COVID-19 (t75). Ten topics showed an increasingly higher prevalence over time among physicians when

compared to nurses: financial concerns (t1, t63, t99), medical (t11), and residency positions (t26), testing positive for COVID-19 (t32), physician practice (t34), treatment of COVID-19 patients (t83), and positive interactions with other users online (t91). On nine topics the posting prevalence was initially higher among physicians, but the difference decreased over time: evidence for treatment of patients (t3), COVID-19 in children (t7), testing for COVID-19 (t10), intubation of patients (t30), the early spread of the pandemic in Italy (t55) and China (t74), scientific studies discussing evidence about the virus (t58, t61), and hydroxyl chloroquine (t95). On four topics, the posting prevalence was initially higher among nurses, but the difference

■ Topics increasing in prevalence over time ■ Topics decreasing in prevalence over time ■ Topics showing no significant change in prevalence over time

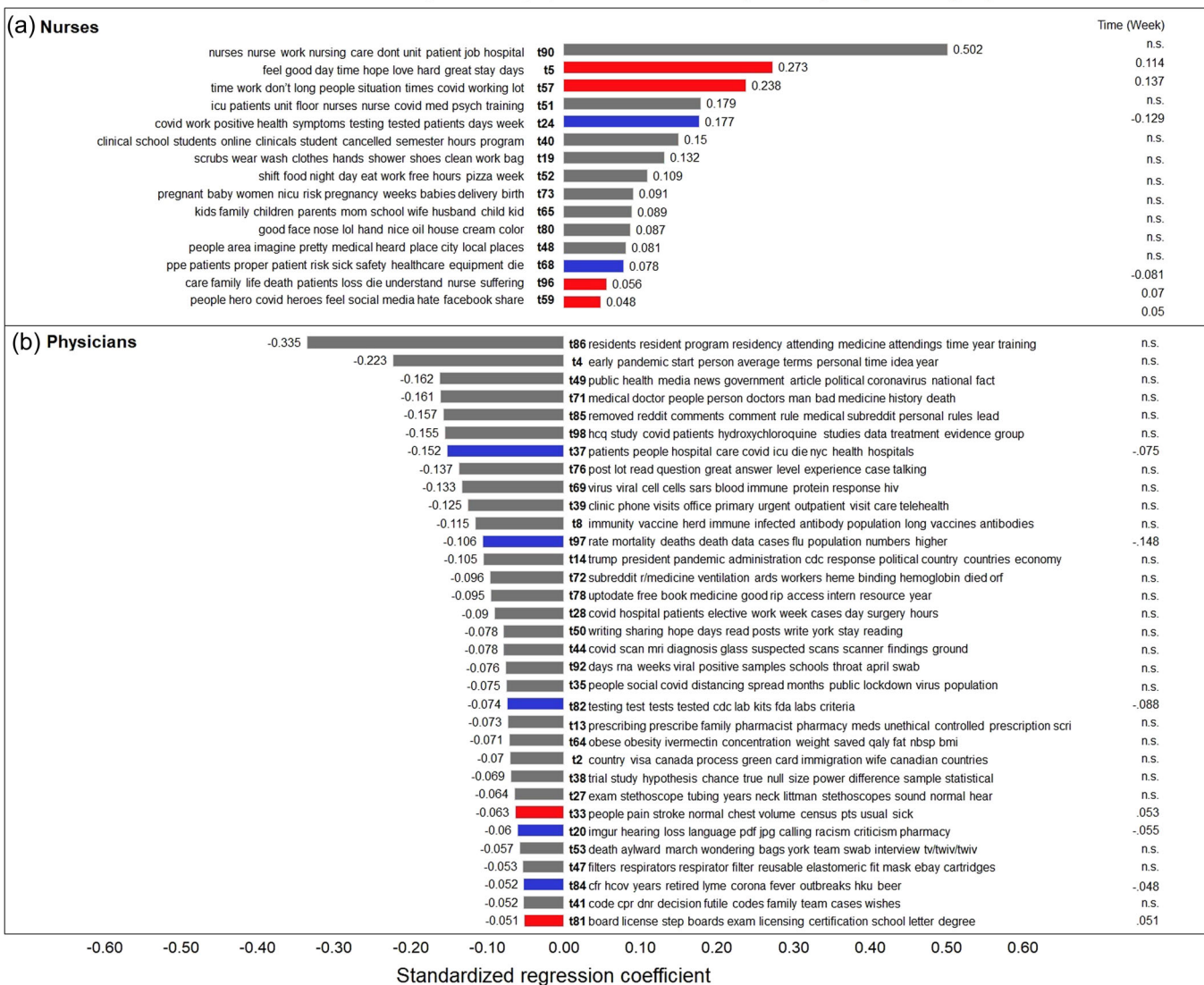


FIGURE 2 LDA topics showing different prevalence across professions (physician, Panel [b] vs. nurse, Panel [a]) but a similar trend across time (red bar = increasing prevalence over time; blue bar = decreasing prevalence over time; gray bar = no change in prevalence over time). LDA, Latent Dirichlet Allocation. [Color figure can be viewed at wileyonlinelibrary.com]

decreased over time: personal protective equipment (t9, t43), CDC guidelines on airborne/droplet precautions (t31), and expression of anger and frustration (t42).

Finally, 25 topics that showed no differences in prevalence between professions are listed in Tables 3 and 4. Three topics increased in posting prevalence over time by both professions: mental-health issues, medications (t23, t46), and street protests (t22); while three other topics decreased in prevalence over time: quarantine (t36), COVID-19 symptoms (t21), and contact-tracing (t18) (Table 3). Nineteen topics that did not differ in prevalence between professions or across time involved work conditions such as scheduling, staffing, and patient flow (t12, t25, t70), PPE supplies (t77), medical procedures and conditions (t56, t87, t89, t94), getting fired (t66), sick leave (t67), chiropractic medicine (t6), and miscellaneous topics including COVID-19 video links (t93) and conspiracy

theories (t16, t60), online discussion rules (t45), and Spanish words (t100).

4 | DISCUSSION

Several key findings emerged from this exploratory study of the social media postings of nurses and physicians in the first 4 months of the COVID-19 pandemic. The most prevalent topics for both professions reflected the adverse impact of extreme hazards and exhausting physical and emotional conditions at work on the one hand, and attempts to maintain a positive emotional outlook personally and to provide encouragement and support to colleagues and trainees on the other hand. Broader concerns about the scope of the pandemic and its long-term impacts on professional development

emerged increasingly over time. Notable differences between postings by nurses and physicians also were identified. Nurses were more likely than physicians to post about feeling insufficiently protected from the hazard and burden of intensive exposure to patients infected with and suffering and dying from the virus. Nurses also often provided support to one another, including empathizing about the challenges nurses faced due to being responsible for providing emotional support to patients' families while simultaneously feeling separated from and worried about their own families. Physicians initially tended to post more about technical and clinical/diagnostic issues, but over time increasingly expressed similar concerns to those voiced by nurses about the personal impact of the pandemic's physical and emotional stressors and emotional support for their colleagues. These findings have several implications for the healthcare professions that will be discussed.

While there were changes over time in their postings that corresponded to the progression of the pandemic, both nurses and physicians consistently expressed concern about the personal threat posed by COVID-19 (e.g., testing and treatment for COVID-19; mitigation of danger with PPE and other precautions). They described the severe discomfort related to hazardous and exhausting work

conditions and extended use of PPE, both of which have been shown to have adverse health effects (e.g., frequent and severe headaches [Ong et al., 2020]). They also often posted about attempts to cope with the demands and threats posed by COVID-19 by maintaining high quality clinical practice and providing preparatory training (Alharbi et al., 2020; Chirico et al., 2020; El-Hage et al., 2020; Gavin et al., 2020; Ornell et al., 2020; Petzold et al., 2020).

Over the 4 month time period at the beginning of the COVID-19 pandemic (January 21 to June 1, 2020), nurses' and physicians' posts also reflected increasing concern about the international scope of the pandemic (most notably in China and Italy), and the concurrent upsurge in public protests against racial violence and inequities. This broader perspective was accompanied by increasingly frequent postings expressing anger and exhaustion due to unremitting health risks, exposure to patients' suffering and deaths, the burden of caring for terrified, angry, and grieving families, (Shanafelt et al., 2020; Zaka et al., 2020). Recognition of the unprecedented barriers to professional development (e.g., licensing, board certification, job finding) created by the pandemic, and ambivalence about being lauded as heroes on social media, also increasingly was voiced. By contrast, as the procedures and equipment necessary for safety and

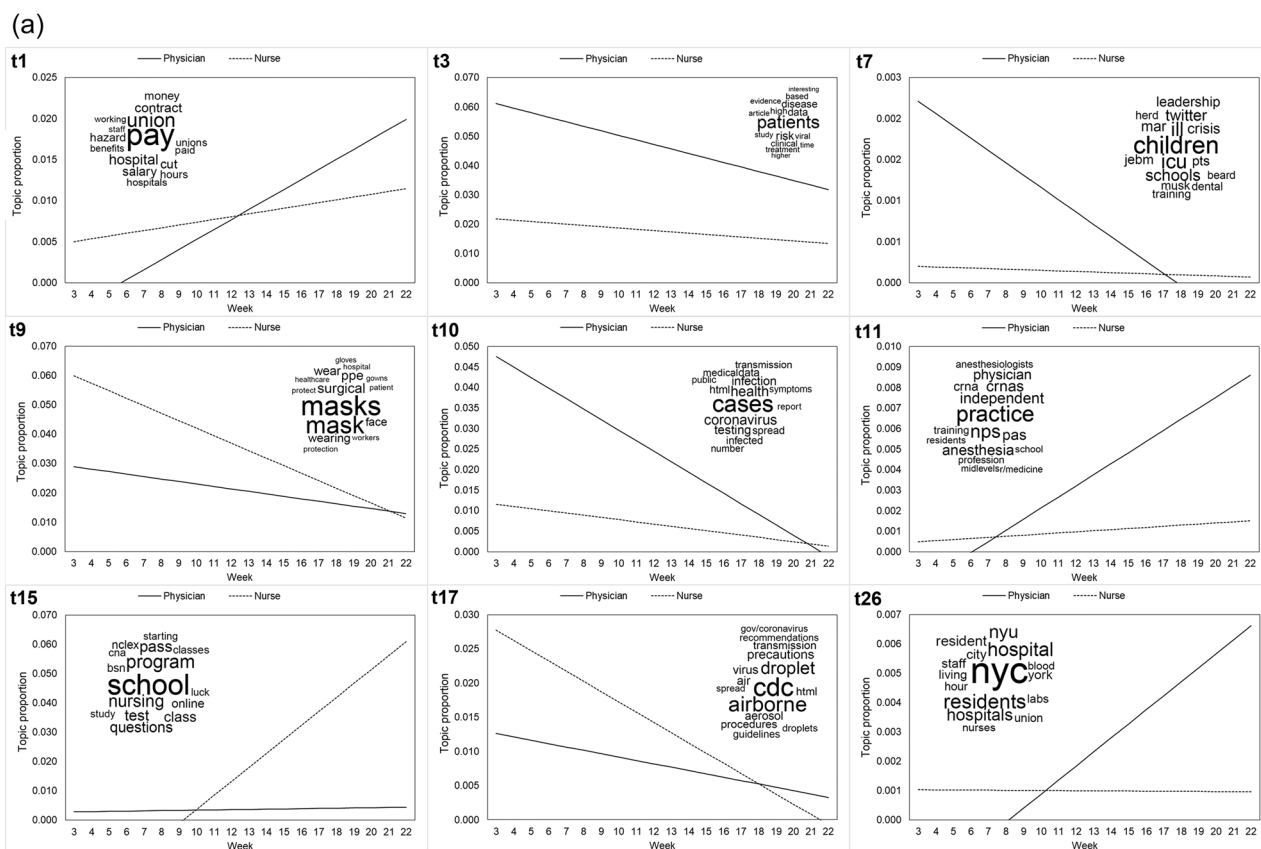
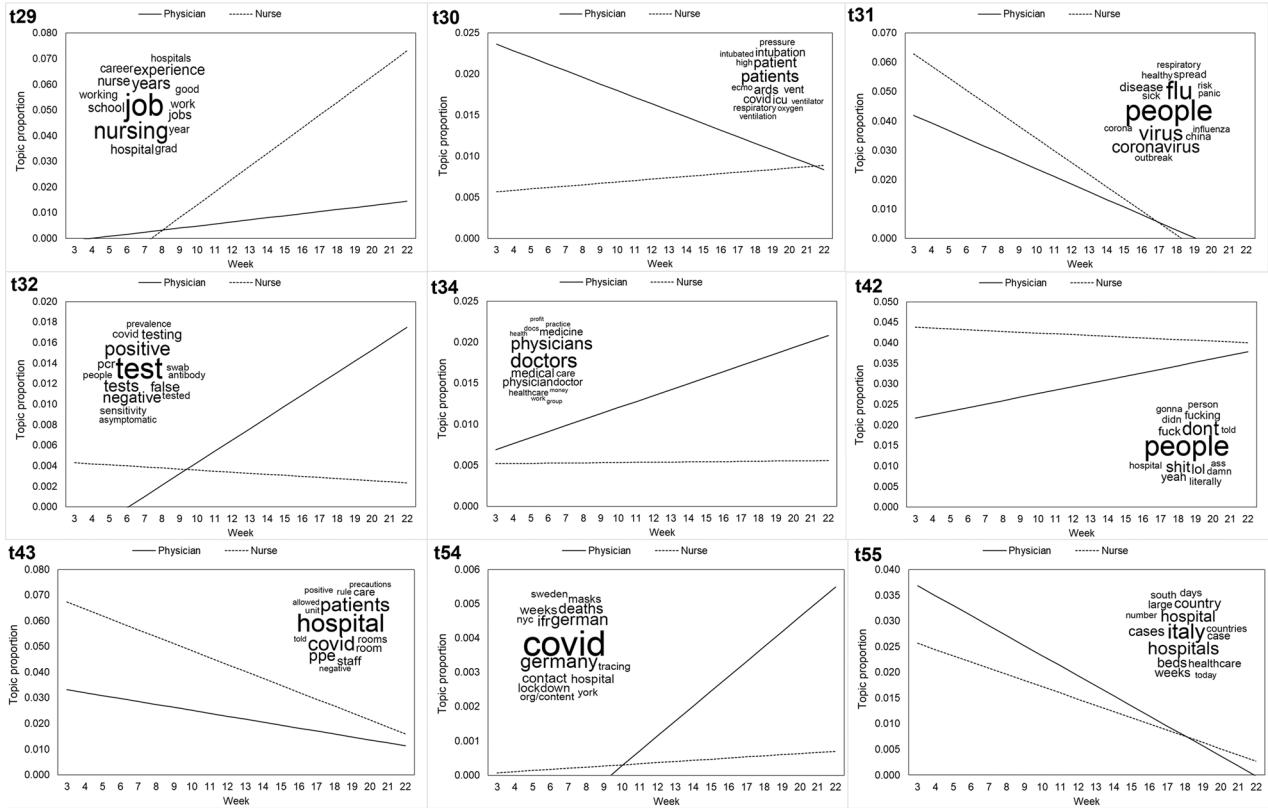


FIGURE 3 (a) Interaction effects: Topic proportion scores by time of discussion (week) and profession for topics t1–t26 (physician vs. nurse) (font size indicates relative prevalence of topics). (b) Interaction effects: Topic proportion scores by time of discussion (week) and profession for topics t29–t55 (physician vs. nurse) (font size indicates relative prevalence of topics). (c) Interaction effects: Topic proportion scores by time of discussion (week) and profession for topics t58–t98 (physician vs. nurse) (font size indicates relative prevalence of topics).

(b)



(c)

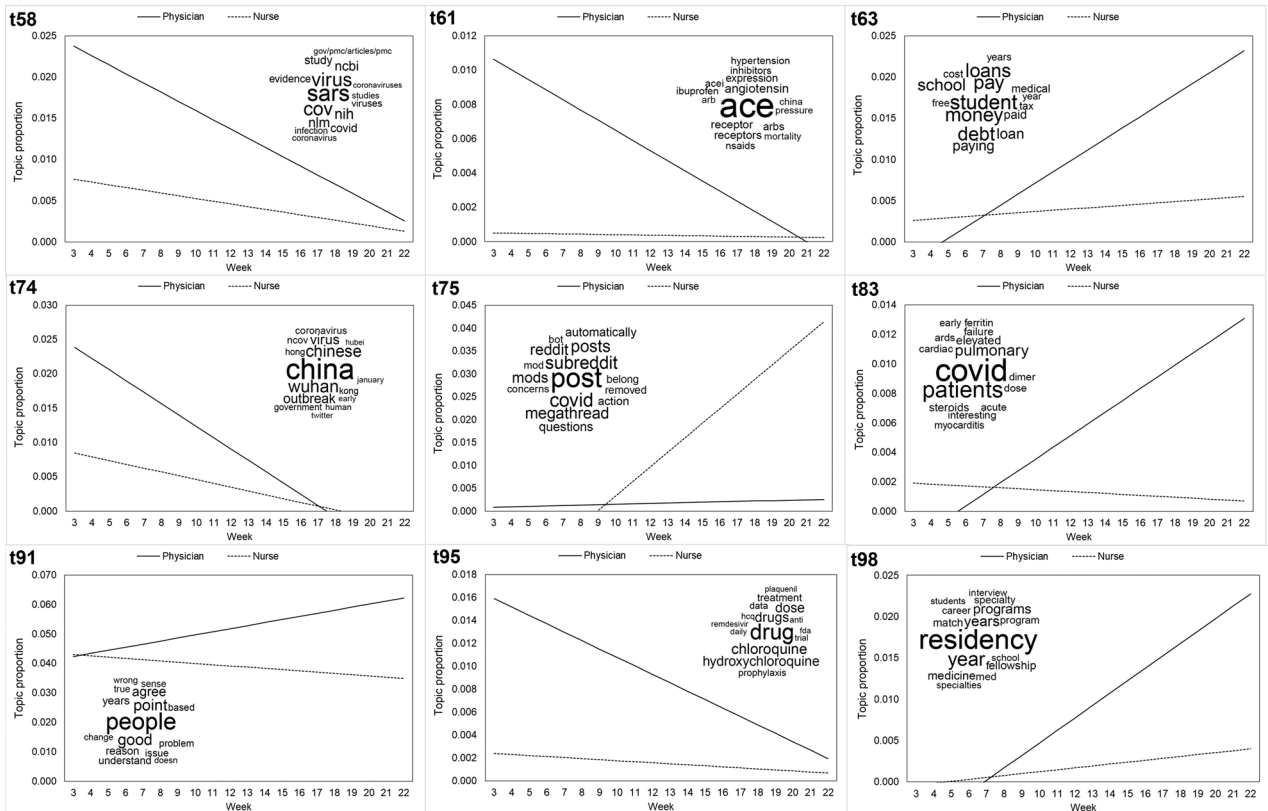


FIGURE 3 (Continued)

patient care became, respectively, more routine and more available, postings about treating viral symptoms, quarantine, and contact tracing were decreasingly prevalent.

Additionally, both nurses and physicians increased the frequency of postings related to mental health problems and treatment for themselves and their colleagues. This is consistent with recommendations of the WHO, the United Nations, and the International Red Cross Society to prevent or ameliorate mental health problems among frontline COVID-19 health workers (Petzold et al., 2020). Posts indicated an increasing degree of personal concern about adverse mental health impacts (e.g., depression, anxiety, sleep problems). This is consistent with evidence that not only frontline nurses, physicians, and other healthcare workers (J. Z. Huang, Han, et al., 2020; Jun et al., 2020), but also healthcare professionals and workers who have limited to no direct contact with virally-infected patients may experience mental health problems such as symptoms of anxiety or depression (Lai et al., 2020; Liang et al., 2020; Wu et al., 2020) and burnout (Wu et al., 2020).

Nurses posted more often than physicians regarding concerns about workload, personal danger, and safety precautions (including nursing practice and training, use of PPE, and hygiene), as well as to provide positive emotional support to their colleagues. This matches evidence that nurses have greater viral exposure than physicians and as much as three times higher rates of testing positive for the virus than physicians (and five times the rate of nonmedical personnel) (von Freyburg et al., 2020). It also is consistent with evidence that provider well-being, safety, and mutual support are core values in the nursing profession (Zeller et al., 2011), and have been shown to be associated with nurses' occupational satisfaction, intention to remain in the job, and capacity to provide safe and effective patient care (Aiken et al., 2021).

Nurses also posted more often than physicians about issues that had an immediate impact on them, including patients' deaths, concerns related to their own family, risks to pregnant women, availability of healthcare, and how they as healthcare professionals were praised or criticized on social media. This is consistent with survey findings early during the pandemic showing that nurses report higher levels of anxiety, depression, insomnia, and distress than physicians (J. Z. Huang, Han, et al., 2020; Lai et al., 2020). However, similar to our social media findings, nurses interviewed in Wuhan expressed positive emotions in combination with negative emotions (Sun et al., 2020), reflecting their resilience and the importance of counterbalancing fear and grief with hope and compassion satisfaction (i.e., satisfaction with work as a result of feeling compassion for patients) (Baek et al., 2020).

Nurses' postings about patients' deaths and their workload were increasingly frequent over time. Thus, while the pressure of intense workloads and the traumatic impact of actual and threatened death on nurses may have seemed to have abated after the first surge of cases and hospitalizations (Sun et al., 2020), over the course of several months of the pandemic nurses' concerns about the danger and pressures they and their coworkers face continued to rise rather than diminish. Consistent with interview results early in the pandemic

in which nurses reported many ways of adaptive coping with pandemic-related stressors (e.g., altruistic acts, self-reflection, positive reappraisals, and team support) (Cai et al., 2020; Sun et al., 2020), in Reddit social media postings, nurses increasingly often expressed positive emotional support and appreciation for colleagues. This is consistent with survey findings that social support was a protective factor for healthcare professionals in the first months of the pandemic, as indicated by its association with better sleep quality (Xiao et al., 2020) and lower risk of severe anxiety (Ni et al., 2020; Petzold et al., 2020). Mental health promotion and prevention programs for healthcare professionals and workers that emphasize increasing social support (Alikhani et al., 2020; Q. Chen, Liang, et al., 2020; Greenberg et al., 2020; Zaka et al., 2020) should consider explicitly including social media communications between those professionals as a forum for mobilizing support.

By contrast, nurses' posts about testing positive for COVID-19 and use of PPE declined in frequency over time. This may have reflected increased professional confidence and personal growth under pressure (Alharbi et al., 2020), which was a theme in interviews with Chinese nurses after the first 4–6 weeks of the pandemic (Sun et al., 2020). Alternately, it may have been due in part to nurses becoming resigned to the chronic shortages of testing and PPE, which would be consistent with nurses' elevated levels of anxiety, depression, and distress in the first 2 months of the pandemic (Q. Chen, Liang, et al., 2020; J. Z. Huang, Han, et al., 2020; Lai et al., 2020).

Physicians posted more often than nurses about technical aspects of the coronavirus disease and related medical equipment and physician practice, patients' symptoms, diagnoses, and treatment in severe cases (including patients dying). Physicians also posted about clinical trials and public policies related to the pandemic more often than nurses. This is consistent with role definitions for physicians that emphasize overseeing the care of patients with complex severe conditions (Comfort et al., 2022) and advocacy for public healthcare policies (Gaeta & Brennessel, 2020). However, this should not be taken to support hierarchical stereotypes that confer an elite status on physicians and place nurses in a subordinate role. Physicians (Logghe et al., 2018), nurses (Hoeve et al., 2014), and social media (Onyango & Bowe, 2019) are challenging role definitions that place physicians above nurses in status and responsibility to support team work by the two professions as coequals (Sollami et al., 2015).

Over time, physicians continued to post at stable levels on most of those topics, with an increase only in posts on patients' chest pain, and a decreasing frequency of posts on testing for COVID-19, mortality rates, and patients dying. Physicians' posts also showed a greater increase over time than nurses' posts in discussions of the personal impact on them financially, their safety, and their professional practice, employment, and training. Physicians also posted messages of positive emotional support for colleagues increasingly over time. Where nurses articulated personal concerns and the importance of protecting their own and their trainees' safety early in the pandemic, physicians' posts reflected a primary concern with the clinical response in the early weeks and only began to frequently address personal reactions and concerns for themselves and their

trainees after the pandemic had continued for months (Abbasi, 2020; El-Hage et al., 2020; Greenberg et al., 2020; Ornell et al., 2020; Shanafelt et al., 2020). This is consistent with nurses being at greater risk than physicians of infection (Barrett et al., 2020) and vicarious trauma (Vizheh et al., 2020) due to more extensive interaction and bedside care with patients who were suffering and dying (L. Huang, Lin, et al., 2020).

Topics on which the professions posted with similar and relatively constant frequency over time centered on concerns about threats to healthcare workers' personal and job safety, intensive lifesaving or palliative treatments (e.g., intubation, sedation, dialysis), and controversies (e.g., conspiracy theories, whether chiropractic treatment is appropriate for patients infected with the virus, the pros and cons for healthcare professionals to volunteer for hazardous duty or to work past the point of exhaustion). Thus, both physicians and nurses appeared to remain consistently and understandably aware of and concerned about the challenges of providing care under extreme conditions with patients at high risk, and the serious dangers that the pandemic posed to their health and job security and that of their colleagues and coworkers.

5 | LIMITATIONS

Study limitations include the reliance on postings by professionals who may not be representative of physicians or nurses in general or specific subgroups (e.g., professionals who are less familiar with, able to access, or inclined to communicate via social media). The postings also may have been made by professionals working on the frontlines for amounts of time that could have varied from not at all to intensively for prolonged periods, and in different settings with differing degrees of exposure and related hazards. Further, the postings cannot be assumed to represent the enduring beliefs of or factual observations by the senders, as social media messaging is influenced by many factors that could not be assessed in this study (e.g., transient emotional reactions, long-term as well as contemporaneous stressors, implicit social norms). Important professional and practice characteristics (e.g., trainee vs. independent practitioner, years of experience, subspecialty) other than physician versus nursing profession could not be ascertained. Nor was it possible to distinguish amongst the posting professionals based on sociodemographic variables such as gender, age, marital status, or nationality. The pandemic's impact also differed over this time period for healthcare professionals in different parts of the world, but the geographical location of each posting could not be discerned to correlate the timing of postings with the extent of the pandemic in the location from which the posting originate. Postings with references to the New York City area also were prevalent, which may limit the generalizability of study findings but is consistent with that area (and its trauma centers) being the first United States epicenter of the COVID-19 pandemic during early spring 2020 (Liveris et al., 2022; Thompson et al., 2020).

6 | CONCLUSION

Overall, results highlight health professionals' concerns as the pandemic unfolded in the first months, and their resilience (Bohlken et al., 2020; De Vitis et al., 2020; Zhan et al., 2020). The prevalence of messages by nurses early on, and somewhat later by physicians, were characterized by positive emotions and support for colleagues reflects the importance that health workers place upon finding meaning and mutual support in times of crisis' (Alharbi et al., 2020; Chirico et al., 2020; El-Hage et al., 2020; Gavin et al., 2020; Ornell et al., 2020; Petzold et al., 2020)

The most distinct differences in messaging frequency between the professions may reflect an initial focus by nurses on the personal impact of illness and suffering on patients and their families, and on themselves, in contrast to a focus on technical, procedural, and scientific issues and questions by physicians—consistent with their differing professional role definitions and responsibilities. Interestingly, over time this difference narrowed, as nurses increasingly made technical posts, while physicians' posts increasingly dealt with the personal domain. It may be important to provide support early in crises for nursing professionals that emphasizes the personal impact that they and their patients are dealing with. Physicians by contrast may be best supported by the communication of clear scientific, technical, and policy standards and initiatives. However, both facets of professional work, the personal and the technical, ultimately appear to be important to both professions, just in a sequence best geared to each profession (e.g., for nurses, beginning from the outset of a crisis; for physicians, after technical/clinical adaptations have been made in a crisis and the cumulative personal impact becomes evident).

These social media postings by nurses and physicians provide a unique window into the challenges they faced during the emerging crisis of the COVID-19 pandemic, their resilient response, and the impact this had on them professionally, emotionally, and interpersonally. Many of their postings also reflected efforts to advocate for themselves and their colleagues, which highlights the importance of mobilizing public and institutional support not only for the dedication and service to their patients and communities, but also for the role of nurses and physicians as public health advocates using social media to communicate their experiences.

AUTHOR CONTRIBUTIONS

Julian D. Ford: project administration, conceptualization; methodology; resources; writing-original draft; writing-review & editing. **Davide Marengo:** conceptualization; data curation; formal analysis; investigation; methodology; visualization; writing-original draft; writing-review & editing. **Miranda Olf, Cherie Armour, Jon D. Elhai, Zack Almquist, Emma S. Spiro:** conceptualization; methodology; writing-review & editing.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data are available upon request from Dr. Davide Marengo (davide.marengo@unito.it). Data were collected only from social media postings of healthcare professionals. All data were extracted deidentified from a publicly available website.

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PEER REVIEW

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