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Impacts of biomedical hashtag-based Twitter campaign: #DHPSP utilization for promotion of open innovation in digital health, patient safety, and personalized medicine

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ABSTRACT

The open innovation hub Digital Health and Patient Safety Platform (DHPSP) was recently established with the purpose to invigorate collaborative scientific research and the development of new digital products and personalized solutions aiming to improve human health and patient safety. In this study, we evaluated the effectiveness of a Twitter-based campaign centered on using the hashtag #DHPSP to promote the visibility of the DHPSP initiative. Thus, tweets containing #DHPSP were monitored for five weeks for the period 20.10.2020–24.11.2020 and were analyzed with Symplur Signals (social media analytics tool). In the study period, a total of 11,005 tweets containing #DHPSP were posted by 3020 Twitter users, generating 151,984,378 impressions. Analysis of the healthcare stakeholder-identity of the Twitter users who used #DHPSP revealed that the most of participating user accounts belonged to individuals or doctors, with the top three user locations being the United States (501 users), the United Kingdom (155 users), and India (121 users). Analysis of co-occurring hashtags and the full text of the posted tweets further revealed that the major themes of attention in the #DHPSP Twitter-community were related to the coronavirus disease 2019 (COVID-19), medicine and health, digital health technologies, and science communication in general. Overall, these results indicate that the #DHPSP initiative achieved high visibility and engaged a large body of Twitter users interested in the DHPSP focus area. Moreover, the conducted campaign resulted in an increase of DHPSP member enrollments and website visitors, and new scientific collaborations were formed. Thus, Twitter campaigns centered on a dedicated hashtag prove to be a highly efficient tool for visibility-promotion, which could be successfully utilized by healthcare-related open innovation platforms or initiatives.

1. Introduction

Open innovation represents a concept that counters the traditional industry-practiced innovation generation, which is based on secrecy and reliance on internal company expertise. In a more collaboration-oriented approach, open innovation aims to harness benefits associated with synergistic incorporation of extrinsic expertise and externally generated innovation in the development of new ideas or products (Hodson, 2016; Hunter and Stephens, 2010).

Digitalization is profoundly changing multiple industries and societal segments, and the healthcare system is also part of this transformation (Alami et al., 2017; Gopal et al., 2019). Since digital tools provide multiple new ways for connection and communication, their application in the context of healthcare is expected to provide a significant boost for open innovation (Hopia et al., 2015; Murphy et al., 2020). Similarly, significant impacts of digitalization are already happening in the areas of patient safety (Atanasov et al., 2020; Classen et al., 2018; Dašić et al., 2017) and personalized medicine (Abul-Husn and Kenny, 2019; Blasiak et al., 2020).

The Ludwig Boltzmann Institute for Digital Health and Patient Safety (LBI-DHPS) was established in 2019 as a new institute in the frame of the extra-university research establishment Ludwig Boltzmann Society at the Medical University of Vienna, Austria. A unique newly developed "Open Innovation in Science" process was utilized for the institute establishment, which was awarded the prestigious *ICPerMed 'Best Practice in Personalised Medicine' Recognition 2019*, for best open innovation in science practice (https://www.icpermed.eu/en/icpermed-recognition-2019.php). The primary aims of the newly established institute are empowerment of patients and healthcare professionals with digital tools and stimulation of innovative research and development of products and solutions in the domain of digital health and patient safety. One of the initiatives started within the new institute was the establishment of the open innovation hub, Digital Health and Patient Safety Platform (DHPSP), which aims to bring together in a collaborative environment scientists from different specialties, industry representatives, healthcare professionals, patient and patient organization representatives, and everybody else interested in the topics digital health, patient safety, and personalized medicine (https://digitalpatientsafety.com/). The long-term goal of DHPSP is to harness open innovation approaches to stimulate collaborative research and the development of new digital products and personalized solutions aiming to improve human health and patient safety. Founded in May 2020, one of the first major tasks of the DHPSP was to capture the attention of relevant audiences and potential future platform-participants with the use of a combination of approaches, such as providing relevant useful information on the platform website, establishing new research collaborations, publishing of relevant scientific articles and press releases, participation in specialized events, and use of social media channels for dissemination of pertinent information.

Hashtags represent relevant terms or phrases spelled without spaces and with a hash sign (#) in front, and they have been widely used for tagging relevant content on social media (Otsuka et al., 2016). Previous research found that hashtag use on Twitter is an efficient tool (1) to increase the visibility of scientific meetings and conferences (Callister et al., 2019; Cheung et al., 2018; D'Anna et al., 2019; Ferguson et al., 2014; Nason et al., 2015; Negrón, 2019), (2) to form Twitter-based journal clubs (Gardhouse et al., 2017), (3) to monitor online discussions focused on relevant biomedical topics (Balasubramanian et al., 2020; Bundy et al., 2018; Grabbert et al., 2020; Hage et al., 2018; Salem et al., 2016; Yu et al., 2020), (4) to address specific aspects such as the public disclosure on social media of identifiable patient information by healthcare professionals (Ahmed et al., 2020a), (5) to build focused Twitter chats (Carroll et al., 2017), and (6) to be used for rapid dissemination of information in medical crises (Kudchadkar and Carroll, 2020). The major feature of Twitter is that it enables registered users to publicly share short 280-character texts, also known as tweets, which may contain hashtags, hyperlinks, mentions of other users, and sometimes even attached images or video clips. Aside of being a broadly used platform, what makes Twitter one of the preferred social media research sources is the availability of powerful inbuilt Twitter Analytics feature, as well as the availability of many external tools that can extract information on visibility-associated parameters such as impressions (number of times that specific tweets were seen), engagements (number of times that users interacted with specific tweets), and retweets (re-posts of specific organic tweets).

In this work, we aimed to evaluate the effectiveness of a Twitter campaign centered on using the hashtag #DHPSP as a tool to promote the visibility of the DHPSP initiative and form a new Twitter-community with interests in the scientific areas represented by DHPSP.

2. Methods

#DHPSP was registered as an official healthcare hashtag with the Healthcare Hashtag Project (https://www.symplur.com/healthcare-hashtags/) on 17th of October 2020, and monitoring of tweets containing #DHPSP was started after three days and lasted for 5 weeks (20.10.2020–24.11.2020). With the beginning of the #DHPSP hashtag Twitter monitoring, prior or newly joining members of DHPSP were asked to support the visibility-promotion campaign by diverse dissemination approaches, including direct emails or social media messages. The official DHPSP Twitter account (https://twitter.com/DHPSP) served as a central hub for engaging the relevant Twitter community with #DHPSP hashtag postings. The DHPSP website and personal social media accounts of DHPSP members were also used to gain visibility for the newly forming #DHPSP Twitter-community. In addition to Twitter, for extended outreach, #DHPSP-promoting posts were also shared on other social media platforms, including the existing DHPSP channels on Facebook (https://www.facebook.com/DHPSP) and LinkedIn (https://www.linkedin.com/company/digital-health-and-patient-safety-platform/). The goal of these #DHPSP hashtag-featuring postings on other social media platforms was to raise awareness and attract more users to participate in the ongoing #DHPSP campaign on Twitter, taking into consideration that many users have accounts on diverse social media platforms. The tweets containing #DHPSP were monitored and analyzed with the social media analytics tool Symplur Signals (https://www.symplur.com/products/signals/).

Ethical approval was not needed for the hashtag analysis study since it is entirely based on information (tweets) published in the public domain, and the identity of the individual Twitter users will not be disclosed in this work.

3. Results and discussion

For the five monitored weeks, from 20th of October to 24th of November 2020, there were 11,005 tweets (20.8% of which were organic tweets and 79.2% retweets) containing #DHPSP, which were posted by 3020 users and generated 151,984,378 impressions (number of times that Twitter users have seen #DHPSP-containing tweets). Considering the covered time-frame (five weeks), the identified number of tweets and users is relatively high as compared to other previously studied hashtags with biomedical relevance. Thus, #MaleInfertility has been reported to have been used in 11,325 tweets by 3241 users for the period August 2015-November 2018 (Balasubramanian et al., 2020), the annual tweets mentioning #Incontinence were reported to be 13,823 in 2015, and the number raised to 19,996 in 2018 (Grabbert et al., 2020), and the hashtag #KidneyStones was reported to have been used in 10,333 tweets by 3426 users over one year (Salem et al., 2016).

The daily number of tweets progressively increased during the study period, with 2–78 tweets per day in the first week and 369–796 tweets per day in the last week (Fig. 1). Most of the users who disclosed a location on their Twitter profile were based in the United States (501), followed by the United Kingdom (155) and India (121). This outcome is not surprising, considering that these are countries with a large proportion of English-speaking populations, and most (80.9%) of the posted #DHPSP-containing tweets were in English. In the same context, it should be noted that China, which is the largest country in the world by population, did not come as a top location since Twitter use is not popular in China. In its place, the alternative microblogging platform Weibo is broadly used there (Li et al., 2020; Yang et al., 2019). In this context, the readers need to be aware that Twitter-based visibility promotion campaigns have limited potential to bring disseminated messages to the population of countries in which Twitter is not popularly used, and this represents an important general limitation of the used approach. Concerning percentage-distribution of #DHPSP-posting healthcare stakeholders who could be classified based on information provided in the Twitter biographies of the users, most of the contributors of #DHPSP posts in the study time-period were individuals or doctors (Fig. 2).

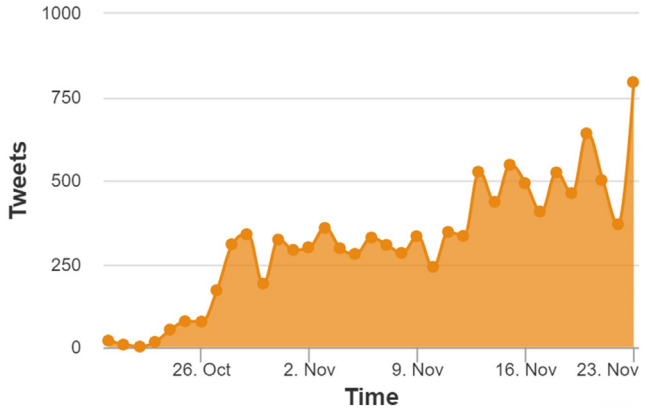

Fig. 1. Daily numbers of #DHPSP-containing tweets during the study period. Tweets containing #DHPSP for the period 20.10.2020–24.11.2020 and were analyzed with Symplur Signals.

To gain insights on prevailing topics shared from the #DHPSP Twitter-community, we analyzed the top ten hashtags co-occurring with #DHPSP (Table 1). Unsurprisingly, the number one top co-occurring hashtag was #COVID19. Indeed, the coronavirus disease 2019 (COVID-19) pandemic has been the leading healthcare challenge of 2020 (Esakandari et al., 2020; Lwin et al., 2020; Pascarella et al., 2020), and the period of this hashtag analysis coincided with peak numbers of new COVID-19 infections in the United States and other countries (https://covid.cdc.gov/covid-data-tracker/). The hashtags ranking on positions 2–9 (Table 1) are with more broad-use direction and are related to medicine and health (#Medtwitter, #healthcare, #health), digital health technologies (#DigitalHealth, #HealthTech, #MachineLearning), or science communication in general (#SciComm, #science). The hashtag ranked on position 10 was #VitaminD, and its high frequency of use was due to several recent scientific works linking vitamin D with COVID-19 (Entrenas Castillo et al., 2020; Hernández et al., 2020; Mercola et al., 2020; Rhodes et al., 2020),

Table 1
Hashtags that were co-occurring with #DHPSP in the analyzed period (20.10.2020–24.11.2020).

Rank	Hashtag	Tweets	Conventional use on Twitter
1.	#COVID19	1,401	To tag tweets related to COVID-19
2.	#healthcare	786	To tag tweets related to healthcare
3.	#DigitalHealth	782	To tag tweets related to digital health
4.	#health	701	To tag tweets related to health
5.	#Medtwitter	700	To tag tweets related to medicine
6.	#SciComm	618	To tag tweets related to science communication
7.	#HealthTech	580	To tag tweets related to health technologies
8.	#MachineLearning	573	To tag tweets related to machine learning
9.	#science	517	To tag tweets related to science
10.	#VitaminD	411	To tag tweets related to vitamin D

which sparked wide discussion in the Twitter-community. Full-text analysis of the #DHPSP tweets also confirmed the prevalence of COVID-19-related postings, with "covid-"being the most frequent word among the 11,005 #DHPSP tweets (Fig. 3).

We also aimed to obtain long-term information (Fig. 4) for the hashtag use and visibility parameters of the DHPSP Twitter account (https://twitter.com/DHPSP) and website (https://digitalpatientsafety.com/) for a total of six months, including the two months in which the hashtag visibility promotion campaign was executed (October and November 2020), the two months preceding the campaign (August and September 2020), and the two months following the campaign (December 2020 and January 2021). A very low rate of #DHPSP hashtag was detected in the two months preceding the visibility promotion campaign (Fig. 4A). Similar low usage has also been observed in the first several days of the campaign (Fig. 1). As expected, the execution of the campaign resulted in a substantial increase in the number of #DHPSP tweets in October and especially in November, and then in the following two months there was some decrease of approximately one quarter to one third. Thus, although there was some decrease in the use of the hashtag after the end of the campaign, its application remained greatly increased compared to the low level

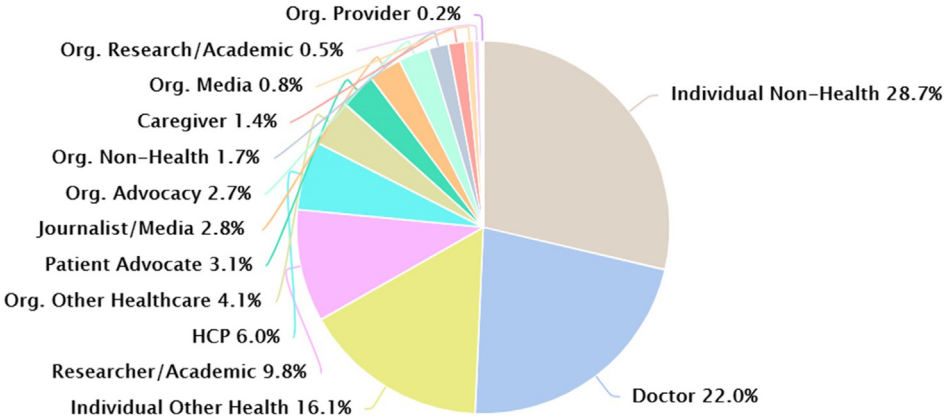

Fig. 2. Percentage of #DHPSP-posting healthcare stakeholders. Definitions according to the glossary by Symplur (listed alphabetically): *Doctor*: Those believed to be licensed, MDs, DOs, PhDs who bill directly for services. Also includes medical residents; *HCP*: Those believed to be other healthcare professionals (i.e., nurses, dietitians, respiratory therapists, nurses, pharmacists, etc.); *Patient Advocate*: Person who publicly self-identify in their Twitter bio as a patient advocate for a specific disease or condition; *Caregiver*: A professional caregiver or a person who is currently or has been a caregiver of a family member or other closely associated individual; *Researcher/Academic*: Person who is working in the field of health-related research and/or academia (A PhD who does not treat patients falls in this category); *Journalist/Media*: Person whose profession is journalism or other news-related media. Doctors who are editors of journals do not get this label; *Individual Other Health*: Person working in the healthcare industry in a nonclinical role; *Individual Non-Health*: Person not known to be directly working in the healthcare industry; *Org. Provider*: Inpatient facilities, medical groups, labs, imaging centers, and other outpatient facilities; *Org. Research/Academic*: Accredited schools of higher learning (i.e., universities, colleges, etc.) and healthcare research institutions/centers; *Org. Advocacy*: An organization focused on a specific set of health issues or medical specialty for the purpose of support, guidance, and education; *Org. Media*: All organizations whose primary purpose is publishing or broadcasting; *Org. Other Healthcare*: Organizations fulfilling roles within the healthcare industry but not providing direct clinical care; *Org. Non-Health*: All organizations not falling into an established category.

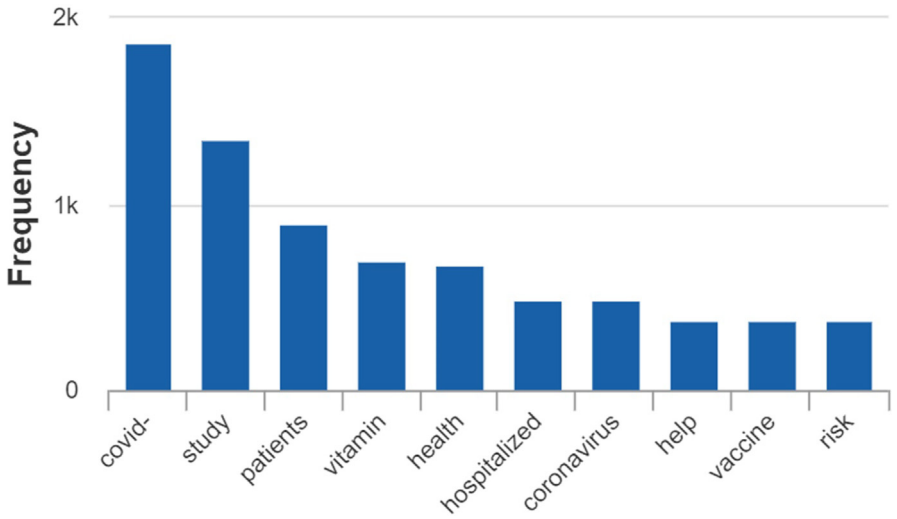

Fig. 3. Top ten most frequently occurring words within the #DHPSP tweets (n = 11,005). Frequency of occurrence of words in tweets mentioning #DHPSP for the period 20.10.2020–24.11.2020 and were analyzed with Symplur Signals.

seen in August-September 2020. Similarly, the numbers of new DHPSP Twitter followers (Fig. 4B), DHPSP Twitter profile visits (Fig. 4C), and DHPSP website visits (Fig. 4D) were highest during the execution of the campaign (October and November 2020) and decreased to some extent in the following two months (December 2020 and January 2021) while remaining higher than the period before the campaign (August and September 2020). Interestingly, increased visibility (reach) for the period of the campaign (October and November 2020) was also evident for the DHPSP Facebook account (Fig. 5).

Since 20.8% of the #DHPSP tweets were organic tweets and 79.2% were retweets, we further aimed to dissect what differences in the hashtag use top ranking will be observed upon separate analysis of only the organic tweets and only of the retweets. Upon analysis of just the organic tweets, the top ten hashtag use ranking was: (1) #COVID19; (2) #health; (3) #DigitalHealth; (4) #healthcare; (5) #Medtwitter; (6) #SciComm; (7) #MachineLearning; (8) #science; (9) #COVID; (10) #INPST. On the other side, analysis of just the retweets yielded the following most frequent hashtag occurrence: (1)

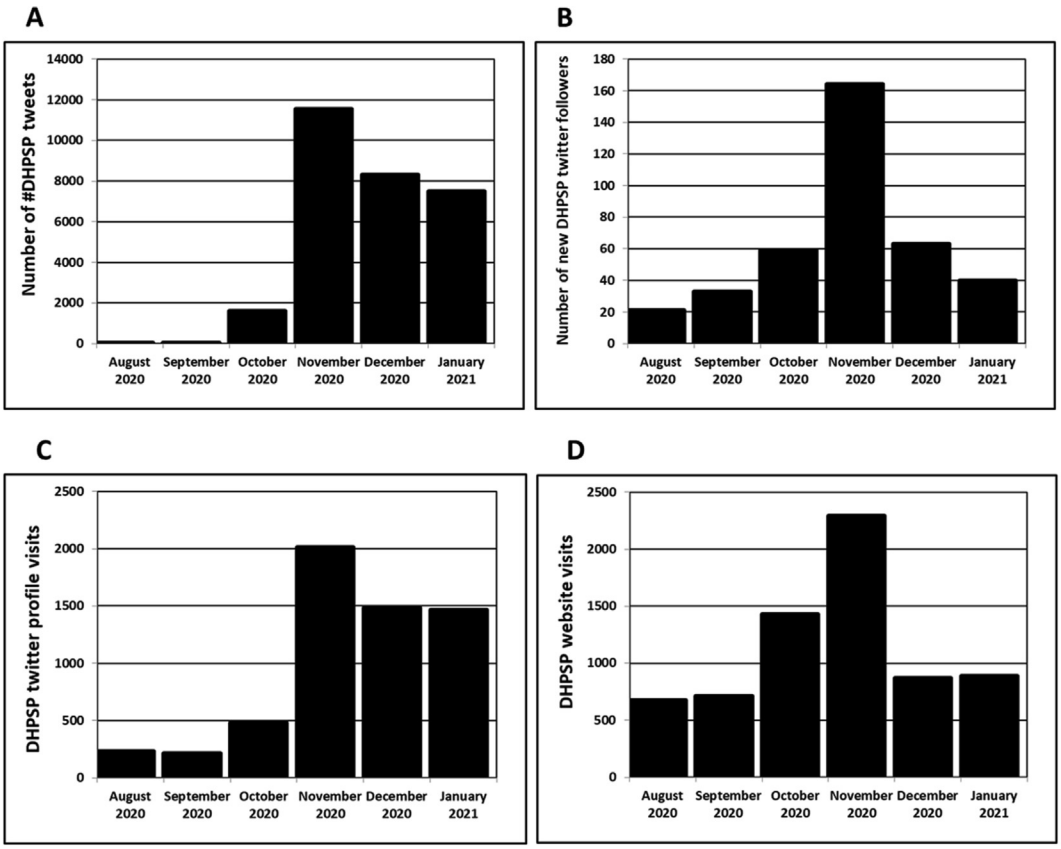

Fig. 4. Numbers of (A) #DHPSP tweets, (B) new DHPSP Twitter followers, (C) DHPSP Twitter profile visits, and (D) DHPSP website visits for the period August 2020-January 2021. The indicated parameters were analyzed for the period 01.08.2020–31.01.2021 with Symplur Signals (A), Twitter Analytics (B, C), or inbuilt website analytics (D).

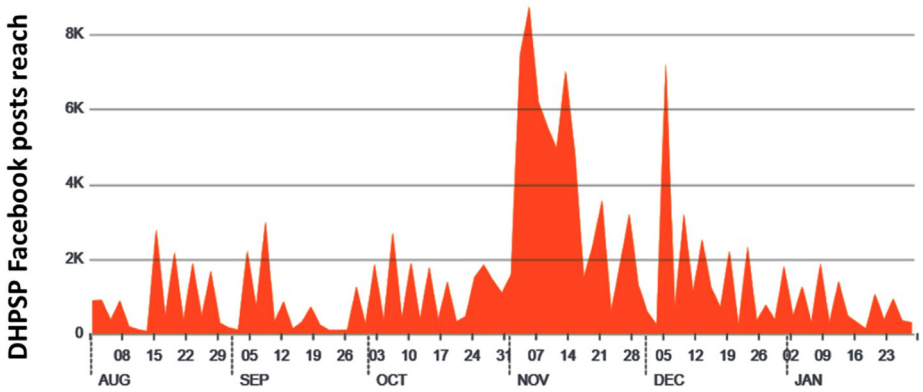

Fig. 5. DHPSP Facebook posts reach (views) for the period 1st of August 2020- 31st of January 2021. The posts reach (the number of people who saw any of the DHPSP Facebook posts for the indicated period) were analyzed with the inbuilt Facebook Page Insights feature.

#COVID19; (2) #DigitalHealth; (3) #healthcare; (4) #Medtwitter; (5) #health; (6) #SciComm; (7) #HealthTech; (8) #MachineLearning; (9) #science; (10) #VitaminD. While in both groups #COVID19 was the top hashtag and the majority of the top hashtags overlapped (8 of 10 hashtags were identical in both groups), there were also few exceptions: present just in the organic tweets set as top hashtags were #COVID and #INPST, and present just in the retweets set as top hashtags were #HealthTech and #VitaminD.

To further explore more long-term developments with the use of the #DHPSP hashtag, we also analyzed the #DHPSP-containing tweets for the first two months of 2021 (01.01.2021–28.02.2021). In the latter period, 14,866 tweets mentioned #DHPSP, which were shared by 2678 users and generated 215,623,867 impressions. These data demonstrate persisting long-term high interest in the use of the hashtag. Moreover, we also aimed to study if there would be some long-term changes in the prevailing themes of the #DHPSP tweets reflected in the identity of the top ten co-occurring hashtags. The performed analysis revealed that for the first two months of 2021 the top ten co-occurring hashtags were: (1) #SciComm; (2) #covid19; (3) #science; (4) #MedTwitterAI; (5) #COVID19Vaccines; (6) #INPST; (7) #research; (8) #COVID19Vaccination; (9) #MedTwitter; (10) #AI. While just 4 of these hashtags are identical to the top hashtags identified during the visibility promotion campaign phase (Table 1), it can still be observed that COVID-19 was among the major themes, with three of the top ten hashtags being #covid19, #COVID19Vaccines, and #COVID19Vaccination. The long-term prevalence of COVID-19-related discussions points out to a potential important application of science-based network initiatives centered on the use of hashtags such as #DHPSP: such campaigns might be used as an opportunity and a valuable tool to educate the general population in topics of extreme biomedical importance such as COVID-19. The latter is of especial importance in the light of the high prevalence of COVID-19 misinformation existing on social media (Ahmed et al., 2020b; Gupta et al., 2020; Tasnim et al., 2020).

Beyond increasing the visibility of the DHPSP website and social media accounts, the conducted visibility-promotion campaign almost tripled the number of DHPSP new member enrollments: while for the 17 weeks of existence of the platform before the campaign there was an average of 3.9 new member enrollments per week, during the conducted campaign the average weekly number of new DHPSP member enrolments increased to 11.6. Even more important application of the campaign and the visibility achieved through it is that several new collaborative work projects were initiated with new DHPSP members who joined during the campaign. These new projects include new research focusing on study of different hashtags with biomedical significance, a new collaborative effort involving meta-analysis of relevant scientific literature, a newly initiated joint work aiming survey of opinions on topics with public health relevance, and a new collaborative initiative aiming the development of a digital tool for patient assistance. Thus, the #DHPSP hashtag-focused visibility campaign successfully achieved its ultimate goal to promote open innovation and stimulate further collaborative research with relevance for digital health, personalized medicine, and patient safety.

4. Conclusions

Starting from a very low basal activity level, in 5 weeks the #DHPSP Twitter campaign yielded a dramatic activity-expansion resulting in a total of 11,005 tweets that generated 151,984,378 impressions and engaged 3020 Twitter users. The significant outreach and visibility achieved by the DHPSP initiative highlight that Twitter campaigns centered on dedicated hashtag use are a highly efficient tool for the promotion of future healthcare-related open innovation platforms or initiatives.

CRediT authorship contribution statement

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Declaration of Competing Interest

Given their role as Editor in Chief, Dr. Atanas G. Atanasov, Dr. Dongdong Wang (Executive Editor), and Dr. Maurizio Battino (Editorial Board Member) had no involvement in the peer-review of this article and had no access to information regarding its peer-review.

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