Public Health Implications of Image-Based Social Media: A Systematic Review of Instagram, Pinterest, Tumblr, and Flickr

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ABSTRACT

Introduction: Image-based social media Instagram, Pinterest, Tumblr, and Flickr have become sources of health-related information and tools for health communication. No known systematic review exists that summarizes the existing research and its health implications.

Methods: We searched EBSCOhost Academic Search Complete, PubMed, and Web of Science in January 2016, April 2017, and November 2017, with the following keywords: *Pinterest, Instagram, Tumblr, or Flickr*. Only public health-related, peer-reviewed research articles were included (excluding surveys of self-reported social media use).

Results: Sixty-six research articles were included. All 12 experimental studies used Instagram. Of the 54 observational studies, 38 studied Instagram; 12, Pinterest; 7, Tumblr; and 6, Flickr; some studies investigated more than 1 platform. More than half of the included articles were related to mental health and substance abuse (n = 39, 59%). Other topics included chronic diseases, infectious diseases, surgery, injury prevention, pharmacovigilance, sexual and reproductive health, and adolescent psychology with functional magnetic resonance imaging.

Discussion: Public health-oriented research on Instagram, Pinterest, Tumblr, and Flickr is increasing. Most observational studies investigated questions ranging from public perception of diseases or interventions (vaccination) and undesirable media exposure ("echo chamber," distorted body image, underage substance use, and pro-suicide messages) to information dissemination and online engagement (likes and comments). A few studies attempted to use image-based social media as intervention tools, but the results were mainly exploratory.

Conclusion: More research is needed to study how social media users discuss health through sharing images online, and how public health professionals can communicate effectively using image-sharing social media.

INTRODUCTION

Images, such as photos, pictograms, and infographics, are powerful tools of health communication[1,2] because of their potential impact on people's knowledge, attitudes, and perceptions regarding health-related issues.[1,3] Health agencies use billboards and photos to promote healthy behavior visually and infographics to present summarized data to the general public.[3] Images are important in communicating health-related information to the targeted demographic.[1] Images reduce the complexity of the message while creating an appealing visual for the audience.[3]

The applications of social media in public health have attracted increasing attention, with relevant systematic reviews published focusing on specific health conditions and interventions[4-8] and specific areas of health-related research.[9,10]

Instagram, Pinterest, Tumblr, and Flickr are examples of social media platforms that emphasize their image-sharing capacities by positioning the image at a prominent location when sharing. (See Sidebar: Origins of Flickr, Tumblr, Pinterest, and Instagram for an overview of the origin of these platforms.) The number of global monthly active users reached 800 million for Instagram and 200 million for Pinterest by 2017.[11,12] In January 2017, 1.3 billion Tumblr posts were published.[13] As of March 2019, there were 90 million monthly users of Flickr.[14]

However, the role of these image-based social media platforms in health communication and public health remains underexplored. A systematic review is essential to better understand the current literature and guide future directions for researchers interested in developing new tools or instruments to explore health communication using such platforms.

This systematic review provides a descriptive overview by health topic of public health-related research on Instagram, Pinterest, Tumblr, and Flickr. Gaps in the literature are identified for future research. The methods to sample and capture images used among the observational studies are summarized to contribute to developing best practices in social media health-related research. We summarize the research literature up to November 2017.

The scope of this systematic review is a priori limited to Instagram, Pinterest, Tumblr, and Flickr. The 4 chosen platforms are examples that the authors considered as having a major presence of still images and where image sharing is an important, if not the most important, feature of the "platform-specific subculture." There is a need to summarize health-related research conducted on these platforms. Although each of these platforms shares certain functions with Facebook, Twitter, and YouTube, such as video-sharing functions and allowing users to post text, readers may refer to published systematic reviews on platform-specific health research pertinent to Facebook,[10,15] Twitter,[16] and YouTube.[17] Also out of scope are instant messenger apps such as WhatsApp (WhatsApp Inc, Menlo Park, CA) and Snapchat (Snap Inc, Venice, CA), and linguocultural-specific platforms

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such as Sina Weibo (Weibo Corporation, Beijing) and WeChat (Tencent Holdings Limited, Shenzhen).

METHODS

The literature search strategy, inclusion and exclusion criteria, and how we assessed the quality of articles were defined a priori. Records were kept for the process for literature search and screening as well as data extraction and quality assessment. We followed Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[18] recommendations and completed the PRISMA checklist (Appendix A[a]).

Figure 1 presents the schematic of our literature search and screening process. We searched EBSCOhost Academic Search Complete, PubMed, and Web of Science with the following keywords: *Pinterest, Instagram, Tumblr, or Flickr*. For Web of Science, our search was restricted to document types of research articles and clinical trials.

We performed 3 rounds of searches. In January 2016, a total of 861 abstracts were retrieved (batch A). In April 2017, restricting to the 2016 and 2017 literature, we retrieved 591 abstracts (batch B). In November 2017, searching the 2017 literature only, we retrieved 633 abstracts (batch C). After removing duplicates and screening abstracts on the basis of the inclusion and exclusion criteria listed in Table 1, we downloaded the full text of the remaining documents for detailed screening (batch A, 46 articles; batch B, 42; and batch C, 41). Each article was given a unique identifier. After removing duplicates and applying the inclusion and exclusion criteria, 66 articles were

Origins of Flickr, Tumblr, Pinterest, and Instagram

Flickr was a pioneer in online photo sharing when the Web site was founded in 2004 and saw its heyday when Yahoo! bought it in 2005. Flickr evolved and found its niche among photography enthusiasts. It was acquired by SmugMug, a paid photo-sharing service, in 2018.[1,2]

Tumblr was founded in 2007 as a microblog that allows users to post multimedia and was acquired by Yahoo! in 2016.[3] In 2012, Tumblr prohibited self-harm materials, including "pro-ana" contents.[4] In 2018, Tumblr banned pornographic contents and triggered a debate on the line between pornography and the arts as well as backlash from certain members of the lesbian, gay, bisexual, transgender (LGBT) communities who feared that certain expressions of their identities were being censored.[5-7]

Pinterest was launched in 2010 as a Web site where users can save an image (known as a "pin") that they upload or find on a Web page onto their "boards," which is a collection of these pins. Other users can "re-pin" these images onto their own boards. Pinterest launched its iPhone (Apple, Cupertino, CA) application (app) in 2011, and quickly became one of the major social media sites.[8]

Instagram was launched in 2010 as an iPhone app, through which users upload and share photos.[9] Instagram became popular for its image filters that enhanced the users' experience. In 2012, Facebook acquired Instagram for $1 billion.[10]

Understanding the historical context of these platforms is important. Flickr was launched in 2004, at a time when the digital camera became popular, gradually replacing traditional cameras that used film. Flickr served the purpose of providing a free platform through which users might organize digital photos as albums and shared them with family and friends. Tumblr was launched in 2007, a year after Twitter was launched, at a time when the idea of a microblog was getting traction. Whereas Twitter's characteristic feature was its brief text message of 140 characters, Tumblr was launched as a microblog that features images. The exponential increase of popularity of Instagram and Pinterest when their iPhone apps were launched in 2010 and 2011, respectively, coincided with the rise of the smart phone and the changing habit of photography by the average nonprofessional user. By mid-2010, smart phones (both iOS and Android operating systems) had become very popular. With a camera on every smart phone, the smart phone had become the camera that everyone carried and used daily. Instead of taking photos with digital cameras and then transferring them to a personal computer or laptop for upload, most smart phone users started taking photos with their smart phone cameras and then uploading them directly from the phone. The iPhone apps of Instagram and Pinterest came onto the market at the right moment in the history of technology and became the dominant image-sharing social media in the second decade of the 21st century.

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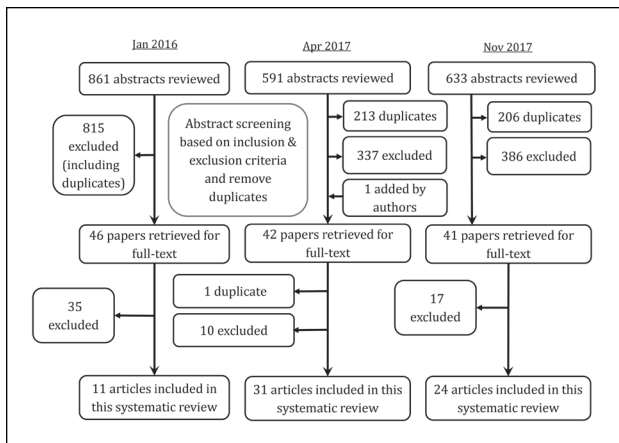
Figure 1. Flowchart of article retrieval process.

included (batch A, 11; batch B, 31; and batch C, 24). For each included article, 2 coauthors extracted the data and assessed the quality of the article independently. In this review, articles are categorized by health topic and study design (observational vs experimental). Extracted data were summarized in Appendix B[a]. Articles excluded after full text retrieval were listed with their exclusion reasons in Appendix C[a]. Details of data extraction and quality assessment methods are in Appendixes D and E[a].

To assess the quality of the articles, including their risk of bias, we followed the approach of a published systematic review on social media use in chronic diseases.[6] We applied the Downs and Black Checklist (excluding question 27) for articles in which the authors performed analysis beyond the basic descriptive statistics[19] (eg, regression analyses),and the Critical Appraisal Skills Programme (CASP) qualitative research checklist[20] (excluding question 10) for articles in which the authors performed basic descriptive statistics only. High scores indicated high quality. To be conservative in our quality assessment, if there were disagreements between the 2 reviewers regarding the scores, we took the lower scores between the 2 for each section in the Downs and Black Checklist and for the total score in the CASP qualitative research checklist.

Given the inherent limitations in the application of these 2 checklists, especially the Downs and Black Checklist, to the literature of social media content analyses, the corresponding author (ICHF) decided to design his own checklist and apply it in this review. The new checklist (Appendix E, Table S16)[a] is designed for assessing the quality of observational studies of public health image-sharing social media studies and is not applied to experimental (intervention) studies. In the new checklist that the corresponding author created, the reporting of social media data retrieval methods was emphasized (5 questions out of 10): Keyword/hashtag (question [Q] 5), tool/method (Q6), specification/limits set (Q7), date/timeframe (Q8) used to retrieve social media data, and whether the sampling method was representative (probability sampling or full dataset; Q9). This was to ensure that published studies can be repeated at least in theory.

We calculated the Cohen κ (Appendix E)[a] for each item in the new checklist using the results of the 2 coders, coding all the observational articles (except the one in Portuguese) for which we used the new checklist.

RESULTS

Fifty-four observational and 12 experimental studies were included (Tables 2 and 3). Among the 54 observational studies, Instagram was studied in 38 articles,[21-58] Pinterest in 12,[22,49,57,59-67] Tumblr in 7,[31,50,68-72] and Flickr in 6.[21,24,57,68,73,74] Some covered 2 or more platforms, with combinations of Instagram and Pinterest,[22,49] Instagram and Tumblr,[31,50] Instagram and Flickr,[21,24] and Tumblr and Flickr,[68] as well as Instagram, Pinterest, and Flickr.[57] In all 12 experimental studies, only Instagram was used.[75-86]

Elements of Social Media Covered

Among the 54 observational studies, contents of social media posts were studied in 47 articles, meta-data of social media posts were studied in 28 articles, and users were studied in 24.[b] All 3 elements (contents, metadata, users) were studied in 11 articles, 2 of 3 elements were studied in 24 articles, and only 1 element was studied in 18 articles.[c] One article reported only frequency of Instagram posts with specific hashtags.[34]

Sampling and Data Capture Among Observational Studies

Methods of image sampling varied among the observational studies and included the following: 1) attempts to capture all posts that met inclusion criteria; 2) random sampling: a) simple random sample of images, b) random sample of images, stratified by time, c) random sample of images but replacing images

Table 1. Inclusion and exclusion criteria		
Criteria	**Inclusion[a]**	**Exclusion[b]**
1	The article is about the public health implications of the use of Instagram, Pinterest, Tumblr, or Flickr, or the use of these platforms as tools for public health interventions or health communication.	The article is not related to the public health implications of the use of Instagram, Pinterest, Tumblr, or Flickr, or the use of these platforms as tools for public health interventions or health communication.
		The article is not about Instagram, Pinterest, Tumblr, or Flickr (eg, a public health research article presenting Twitter data only).
2	The document is an original research article (including a brief report) published in a peer-reviewed journal.	The article is not an original research article (eg, letters to the editor, perspectives, and reviews).
3	The article contains social media data (including meta-data of the posts or the users).	The article reports only self-reported use of image-sharing social media (eg, from surveys or interviews).

[a] Articles were included in this systematic review, if they met all 3 of the criteria.
[b] Articles were excluded if they met any of the criteria.

Table 2. Social media platforms and elements of social media posts studied in 54 observational studies reviewed	
Parameter	**No. of studies**
Social media platforms studied[a]	
Instagram	38
Pinterest	12
Tumblr	7
Flickr	6
Elements of social media covered	
Contents of social media posts	47
Meta-data of social media posts	28
Users of social media	24
All 3 elements	11
Two of 3 elements	24
Only 1 element	18
None[b]	1

[a] Some observational studies covered more than 1 of these 4 platforms, with combinations of Instagram and Pinterest,[22,49] Instagram and Tumblr,[31,50] and Instagram and Flickr,[21,24] Tumblr and Flickr,[68] as well as Instagram, Pinterest, and Flickr.[57]
[b] One article reported only frequency of Instagram posts with specific hashtags.[34]

from the same users with the next images, and d) random sample of time slots to capture images; and 3) nonrandom sampling methods: a) a convenience sample of posts that shown up first, b) posts in the most popular group, c) posts posted by the most popular users, d) the most recent posts, e) the posts showing up, f) every "fifth" post, and g) a small sample over time. Likewise, methods of data capture varied and included: 1) application programming interface (API; see Sidebar: Glossary), 2) firehose (see Sidebar: Glossary), 3) proprietary platforms, 4) screenshots, and 5) recruiting participants who are willing to share their Instagram photos with the researchers. For details, see Appendix D.[a]

Articles by Health Topics

Table 3 summarizes the 66 included articles by health topic and study design. The categories of mental health,[d] and substance abuse[41-51,66,72,82,83] together comprised 39 articles (59%).

Infectious Diseases

Three-quarters of vaccine-related Pinterest images were found to be antivaccine.[59] Two studies categorized Ebola virus-related images, and 2 were on the Zika virus. Among them, 2 were simple thematic content analysis between platforms.[21,22] On top of content analysis, 1 categorized sentiment of the images[25]; another compared between the Instagram images and tweets posted by the Centers for Disease Control and Prevention, the World Health Organization, and Médecins Sans Frontières (Doctors Without Borders) and included engagement analysis (likes and comments).[23]

A correlation ($r = 0.798$) was identified between the dengue incidence in Santa Catarina, Brazil, and social media posts originated from the same state that were specific to mentions of dengue, chikungunya, and Zika. Instagram and Flickr were among the platforms monitored.[24]

Chronic Diseases

Researchers analyzed images related to various chronic diseases: Chronic obstructive pulmonary disease,[60] chronic pain,[68] skin cancer,[67] scoliosis,[27] status epilepticus,[61] and young adulthood cancer.[28] In a pilot photovoice project for adolescents with type 1 diabetes, the 20 participants found using Instagram a positive experience.[26]

Three experimental studies explored Instagram as an intervention tool. As part of a larger intervention in a cluster-randomized experimental study, parents of 50 children in the intervention arm were given mobile phones with preconfigured Instagram accounts. Parents were asked to take photos of the food their children consumed and upload them to the Instagram account; only 50% (25/50) complied. Of the 937 images uploaded, 70% were uploaded by the 3 most active participants' parents.[75]

In another study, participants were exposed to an Instagram image of a black bean veggie burger. The image was experimentally manipulated to have either 105 likes and many positive comments or no likes or comments. Participants were randomly assigned to each group. Individuals with a higher body mass index were found to express a higher behavioral intention to like, share, or comment on the image.[80]

Table 3. Number of included articles by topics and study design (N = 66)[a]							
	Observational			**Experimental**			**All, no. (%)**
Topic	**Number**	**Summary Table**	**References**	**Number**	**Summary Table**	**References**	
Infectious diseases	6	S1	21-25, 59	0	None	None	6 (9)
Chronic diseases	7	S2	26-28, 60, 61, 67, 68	3	S3	74, 76, 79	10 (15)
Mental health (excluding substance abuse)	22	S4	29-40, 48, 50, 62-65, 69-71, 73	4	S5	75, 77, 78, 80	26 (39)
Substance abuse	11	S6	41-47, 49, 51, 66, 72	2	S7	81, 82	13 (20)
Sexual and reproductive health	1	S8	74	1	S9	83	2 (3)
Pharmacovigilance	1	S10	52	0	None	None	1 (2)
Surgery	4	S11	53-56	0	None	None	4 (6)
Injury prevention	2	S12	57, 58	0	None	None	2 (3)
Adolescent psychology with functional magnetic resonance imaging	0	None	None	2	S13	84, 85	2 (3)
Total	54	Not applied	Not applied	12	Not applied	Not applied	66 (100)

[a] Details of articles of each category can be found in the supplementary tables listed in Appendix B (available at: www.thepermanentejournal.org/files/2020/18-307-App.pdf).

A third study evaluated Instagram as a channel to encourage adherence to a home exercise program. Participants in the intervention group received reminders and health education materials via Instagram and reported a higher adherence to the home exercise program, compared with the control group.[77]

Mental Health (Excluding Substance Abuse)

This category included studies on body image and healthy eating, depression, self-harm, and psychogenic nonepileptic seizures.

Body Image and Healthy Eating: Thinspiration (pro-anorexia). A study identified 9 categories of anorexic Instagram images.[38] Pro-anorexic #thinspiration content was found to be prevalent on Pinterest.[62] A network analysis of the interaction within and between pro-anorexia and pro-recovery Flickr communities identified an "echo chamber" (see Sidebar: Glossary) effect, with like-minded individuals communicating more frequently with each other.[73] Importantly, it was found to be counterproductive for pro-recovery users to post comments to pro-anorexia photos because this would make the pro-anorexia individuals continue posting pro-anorexia photos for a longer time. Similarly, the "echo" chamber effect was identified on Instagram, among both the fat acceptance community and the pro-anorexia community.[33] A study found that there were more pro-ana (see Sidebar: Glossary) posts on Twitter than Tumblr, whereas there were more anti-ana (see Sidebar: Glossary) posts on Tumblr than Twitter.[70] Another study found that pro-ana Tumblr posts were more likely to be reblogged at a higher rate than anti-ana posts; users generally did not like to repost a post with a noticeable affective tone, but they did so if the post identified someone as having an eating disorder.[71]

Body Image and Healthy Eating: Fitspiration (see Sidebar: Glossary). An analysis of 50 #fitspiration Instagram images found that these images replicated and extended the contemporary notion of the ideal female body of slenderness.[30] A study found that on Instagram, Tumblr, Facebook, and Twitter, men were featured almost as often as women in #fitspo imagery and men were just as likely to be objectified as women.[31] Two studies on Instagram identified some degree of objectification in most #fitspo[36] and #fitspiration images[37]; their negative side effects on the viewers' body image were suggested.[37] Fitspiration messages were found to include a comparable amount of "fit praise" and "thin praise"[64]; however, these images may create peer support online.[36]

Four experimental studies investigated the relationship between Instagram images and women's body images. In a study, participants who were exposed to fitspiration images reported greater body dissatisfaction and lower state appearance self-esteem than those who were exposed to control stimuli (travel-related images).[76] In a sequel, researchers found that participants who were exposed to celebrity and peer images experienced increased negative mood and body dissatisfaction relative to those who saw travel-related images, whereas the difference between exposure to celebrity vs peer images was insignificant.[78] In a third study, comparing with controls who posted travel-related images, participants who posted "fitspiration" images reported higher scores on bulimia, compulsive exercise, drive for thinness, and drive for muscularity, and had a higher proportion at risk of diagnosis of a clinical eating disorder.[79] In a 3-group comparison study, relative to the control group of neutral images, participants who viewed "fitspiration" images reported poorer self-compassion, whereas participants exposed to self-compassion quotes reported greater body satisfaction, body appreciation, self-compassion, and reduced negative mood.[81] Interestingly, exposure to a combination of "fitspiration" images and self-compassion quotes showed a more positive outcome than those who were exposed to fitspiration images.[81]

Body Image and Healthy Eating: Fatspiration (see Sidebar: Glossary). Images with hashtags #fatspiration or #fatspo were found to more often endorse the theme of fat acceptance than those with hashtags #healthateverysize or #haes. Overall, images with these hashtags often displayed the whole body rather than just the face.[40] A study noted that the fat acceptance community is also an echo chamber.[33]

Body Image and Healthy Eating: Healthy Eating. A study on Scandinavians who had turned 14 years old found that food images were prevalent on their accounts and that it was difficult to monitor adolescents' exposure to marketing of unhealthy food.[32] Infographics about nutrition and healthy eating on Pinterest were found to contain few health behavior theory constructs; recommendations were made for more health behavior theory elements to be included therein to influence healthy eating behaviors.[65] A study characterizing Instagram #cheatmeal images found that

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Glossary

Age gate: A Web page or an interface that requires the user to verify positively that s/he is of a certain age or older. This is to prevent underage individuals from gaining access to online materials that they should otherwise not access.

Anti-ana: Discouragement of anorexic behaviors. This is the opposite of *pro-ana*.

Application programming interface (API): A set of computer codes that allows communication between computers and/or servers. Developers use API to automate the retrieval of social media data from the platforms. However, most social media companies set limits to the amount of data that developers can freely retrieve.

Echo chamber: The phenomenon that social media users interact with other users who share their own viewpoints (eg, regarding politics) and avoid individuals with whom they disagree. These networks of individuals reinforce each other's views.

Fatspiration: A combination of the words *fat* and *inspiration*. This is also known as "fatspo." This term is used by the community who encourages "fat acceptance" (being happy with the fact that individuals are overweight), and this is the opposite of "fitspiration."

Firehose: A firehose API allows developers who pay for the service to download a large volume of social media data from social media platforms that go beyond the free limit set by social media companies for free API download.

Fitspiration: A combination of the words *fit* and *inspiration*. This is also known as "fitspo." This term is used by the community that promotes a slender body shape, but not anorexic.

Pro-ana: Promotion of anorexia nervosa. This is also known as "ana."

Thinspiration: A combination of the words *thin* and *inspiration*. This term is used by the pro-anorexic community.

cheat meals were shown as a goal-oriented dietary practice in pursuit of physique-ideals.[35]

Depression. Depression-focused Pinterest images were found to attract more attention (re-pins, likes, and comments), and half of those images expressed perception of depression as a severe disorder.[63] In a study in which 2 groups of participants, with and without depression, provided consent to the researchers for a 1-time download of all their Instagram images from their accounts, prediction models based on computational features of the images actually made a good prediction if the image was uploaded by someone with depression.[39] Human ratings of photo attributes being "happy" or "sad" also distinguished depressed participants from healthy participants.[39] Nevertheless, the computational features and human ratings did not correlate.[39]

Self-Harm. Images pertinent to depression, suicide, or self-harm were found to be prevalent on Tumblr.[69] Nonsuicidal self-injury content was found by another study to be popular on Instagram.[29] A study on Instagram images with German-language hashtags for nonsuicidal self-injury content found that 8.8% of such images directly depicted wounds, and such images generated around twice as many comments than images that did not directly depict wounds.[48]

Psychogenic Nonepileptic Seizures (PNES). A study found that among PNES hashtags on Instagram, #nead (n = 4331) was the most common, but only one-fourth were related to nonepileptic attack disorder; of #pnes images (n = 1273), three-fourths were related to PNES.[34]

Substance Abuse

This category included alcohol, tobacco, and marijuana and other restricted substances.

Alcohol. Using fictitious Instagram user profiles, a study found that the "age gate" (see Sidebar: Glossary) was not employed on Instagram, and therefore all profiles on Instagram, regardless of age, could be exposed to alcohol industry advertisements.[41] In a survey, researchers created vignettes that described situations in which college students might post images related to alcohol consumption and developed photo stimuli associated with those vignettes. They asked participants to tell whether such photos are more likely to be seen on Facebook, Instagram, or Snapchat. Instagram was found to be the most probable platform for images depicting alcohol use as attractive and glamorous.[82]

Tobacco. Waterpipe-related images were prevalent on Pinterest, Instagram, and Tumblr,[42,66,72] portraying waterpipe smoking positively[66] and becoming part of advertisement campaigns by bars, restaurants, and nightclubs.[42] Policy exemptions were recommended to be removed so that waterpipe use cannot be used as part of commercial advertisement for nightlife businesses.[42] Men were found to post waterpipe-related images more frequently than women did.[72]

Likewise, e-cigarette commercial advertisements are common on Instagram and Pinterest,[44,45,49] where users characterized e-cigarettes as novel devices rather than equivalent to traditional cigarettes.[45] Activity and product-themed images had more likes than advertisements or text-themed images.[44] Customization of e-cigarettes were found among 38% of e-cigarette images on Instagram and in 64% of e-cigarette Pinterest images.[49] In an experimental study, e-cigarette Instagram pages featuring celebrities were found to significantly increase positive attitudes toward e-cigarettes and smoking intentions, compared with those featuring noncelebrities and "products only."[83] Celebrities were rated by participants with a higher trustworthiness, expertise, goodwill, and attractiveness compared with noncelebrities.[83]

A study on Swisher little cigar- and cigarillo-related posts found that one-fourth of the images coded by the authors were also marijuana-related.[46]

Marijuana and Other Restricted Substances. Marijuana images were found to be common on Instagram, including explicit marketing of marijuana that might have the potential to influence social norms surrounding marijuana.[43] Researchers analyzed 2249 Instagram followers of Weedmaps, a Web site for marijuana retail; of these users, 63% were male; 61% were white; 19% were black; 20% were Hispanic; 51% were Californians; and 45% were 20 to 24 years old.[47]

A new approach was developed to automate the detection of drug abuse and drug dealing through using multimodal data on social media.[51] Image and text classifiers were applied to identify drug-related posts from a sample of potential drug-related posts; drug-related accounts were identified through drug-related posts. Accounts were determined if they belonged to drug dealers through timeline data. The positive predictive value (precision) and sensitivity (recall) of this new method were 83% and 68%, respectively.[51]

Sexual and Reproductive Health

Researchers analyzed 40 Flickr images of birthing rooms and found that the technologic birthing room was most dominant, with a focus on medical equipment and the labor bed.[74] Another study manipulated Instagram images with messages about correct and consistent condom use and randomly assigned participants to 1 of 4 groups, in which health information was 1) placed only in the caption, 2) split between the image and the caption, 3) embedded solely in the image, and 4) absent from both the image and the caption. Embedding the message in the image was perceived most effective by the participants.[84]

Pharmacovigilance

Researchers examined the effectiveness of using Instagram for surveillance of drug-drug interactions and adverse drug reactions, using dictionaries on drugs, symptoms, and natural products, and focusing on drugs popular for treating depression.[52] They used the dictionary-based method to categorize Instagram images under different themes, on the basis of the text associated with the images.[52] They used Instagram to perform a population-level behavior analysis of users, using drug, symptom, and natural product dictionaries to tag timelines that discussed common antidepressant drugs.[52]

Surgery

Three descriptive studies of Instagram images related to anterior cruciate ligament surgery,[53] cellular therapy for musculoskeletal conditions,[55] and total joint arthroplasty[56] identified the prevalence of personal recovery stories,[53] advertisements,[55] and tone-positive, postoperative, patient-generated images.[56]

Injury Prevention

Researchers analyzed 176 concussion-related Instagram, Pinterest, and Flickr images, of which 91% reflected the Sports

Concussion Assessment Tool 3 guidelines.[57] In an educational campaign to increase adolescent seatbelt use, images with celebrities wearing seat belts were most liked, whereas postings made at the high school health fair were least liked.[58]

Adolescent Psychology

Two studies found that Instagram images with more likes were more apt to be liked by adolescents[85] and college students[86] than those with fewer likes.

Quality Assessment

Twenty articles were evaluated using the Downs and Black checklist[19] (excluding question 27; maximum possible score of 26), with an average score of 10.65 (standard deviation = 4.37; first quartile = 7.5; median = 11; third quartile = 12.25; range = 4-22). Forty-six articles were evaluated using the CASP checklist[20] (excluding question 10; maximum possible score of 9), with an average score of 7.83 (standard deviation = 0.76; first quartile = 7; median = 8; third quartile = 8; range = 5-9). Fifty-four observational studies were evaluated using the new quality assessment tool (maximum possible score of 10), with an average score of 6.05 (standard deviation = 1.66; first quartile = 5; median = 6; third quartile = 8; range = 1-9). For all 3 checklists, a high score reflects a high quality. See Appendix E[a] for details.

For data pertinent to the ethics statement and funding statements of the reviewed study, see Tables 4 and 5 and Appendix D.[a]

Table 4. Summary of results on ethics, funding of articles reviewed

Parameter	Denominator	Number (%)
Ethics		
Mentioned obtaining approval or exemption from institutional review board or equivalent	66 included articles	28 (42)
Explicitly mentioned participants' written consent[a]	12 experimental studies	6 (50)
Funding[b]		
Reported that their project was funded by specific sources	66 included articles	28 (42)

[a] In addition, 1 observational Photovoice project with human participants mentioned institutional review board approval and participants' consent.[26]
[b] See Table S14 in Appendix B for details and see Appendix D for discussion (available at: www.thepermanentejournal.org/files/2020/18-307-App.pdf).

Table 5. Summary of results on quality assessment of articles reviewed

Quality assessment	No. of articles assessed	Range of scores (maximum score possible)
Scores received using Downs and Black Checklist[a,19]	20	4-22 (26)
Scores received using CASP Checklist[b,20]	46	5-9 (9)
Scores received using the new checklist for observational studies of image-sharing social media	54	1-9 (10)

[a] Question 27 excluded.
[b] Question 10 excluded.
CASP = Critical Appraisal Skills Programme.

DISCUSSION

This systematic review analyzed 66 articles pertinent to the public health applications of Instagram, Pinterest, Tumblr, and Flickr. Instagram was the most studied among the 4 platforms. Mental health and substance abuse were the most studied public health areas among the articles reviewed. Although image-based social media are considered as effective visual communication tools to reach out, concerns have been raised about lack of information diversity in "echo chamber" and exposure to undesirable information (eg, self-harm). For example, the evidence accumulated draws our attention to the effect on teenagers and young adults' body images given the peer comparison in social media when one is exposed to distorted images of peers and celebrities.

The experimental studies reviewed were exploratory in nature. It will take more studies to elucidate the causal relationship between exposures and outcomes, and to identify interventions that work.

Most content analysis studies applied manual categorization of images. A few applied machine learning methods, including Reece and Danforth.[39] These researchers recruited 2 groups of participants who were different in their externally verified clinical status (eg, depression), and they applied both machine learning and manual coding to compare the participants' social media images.[39]

Sampling remains a challenge for content analysis of these platforms. Recent restrictions on API access to Instagram,[87] among others, significantly limit how researchers can download and sample images therein. Notwithstanding privacy concerns, restricted API access is a serious yet underreported collateral damage of the 2018 Cambridge Analytica incident that affected social media research.[88] (Facebook reported that the Facebook information of up to 87 million people may have been improperly shared with Cambridge Analytica, a data analysis company in London, UK.[89]) Importantly, this means that some of the research reviewed here may not be replicable, especially those that downloaded all posts pertinent to a search term and then performed a random sampling. If the research goal is to estimate the prevalence of pieces of (mis)information on a platform, then random sampling of time slots in which a small number of images were captured may offer a solution. An alternative approach is to randomly sample users who posted images pertinent to a search term. For example, among users who posted images pertinent to disease X, how many of them posted misinformation? Given the skewed distribution of number of images posted per user, this would not bias the sample toward the images posted by a tiny group of highly active users. Randomly sampling users ascertains a well-defined sampling frame,[90] and is thus methodologically better than the practice of randomly sampling images and then replacing images from the same users with the next images by users otherwise not selected.

Social media platforms evolve constantly. For example, as of April 2019, Instagram was reported to pilot-test among some users the hiding of the total number of likes an image received in response to concerns about damage done to users' mental health and well-being.[91] This echoes research reviewed here that showed that teenagers and young adults were more likely to like an image if others like it.[85,86]

Future Directions

How and to what extent can image-based social media strengthen the efficacy of health promotion strategies and enable outreach to subpopulations who are less exposed to traditional means of health messaging are important questions to be addressed. To address these concerns, we highlight the following research directions that may fill the gaps in public health research pertinent to Instagram, Pinterest, Tumblr, and Flickr:

1. Research into health topics underrepresented in the reviewed literature (eg, many different infectious diseases other than those covered) is warranted.
2. An experimental study design will help demonstrate causal relationships that observational studies cannot.
3. Methodologic research into how data sampling and retrieval methods affect observational studies' results will help reach a consensus to promote best practice.
4. Image-based machine learning may help streamline content analysis, but this has to be tested and validated in the context of public health research.
5. Obtaining social media posts along with demographic and clinical data from consenting participants will provide new research opportunities. However, the possible bias or general representativeness of willing participants who share social media posts with researchers remains a concern.

Limitations

This systematic review contains several limitations. We limited its scope to 4 social media platforms only to maintain a sharp focus. We acknowledge that there are other social media platforms that also possess image-sharing capacities. We could not include articles published after our third literature search in November 2017; this arbitrary cut-off point was largely a pragmatic logistical decision given the availability of student coauthors to work on this review during an academic year. Articles written in Spanish or Portuguese were reviewed by EBB only given the linguistic barriers of other coauthors. Although acknowledging the potential relevance of other types of published studies (eg, conference proceedings or letters to the editor), we included only peer-reviewed articles to ensure the quality of the data. No meta-analysis was performed because of the heterogeneity of the articles' content (outcome measures, research questions, etc). We chose the Downs and Black checklist[19] (excluding question 27) and CASP qualitative research checklist[20] (excluding question 10) following the example of a published systematic review on social media use in chronic diseases[6]; other researchers might choose to use other checklists. Acknowledging the inherent limitations of the 2 checklists, we developed and tested a new checklist for a more accurate assessment of the quality of observational, social media-based public health research. Notwithstanding its limitations, our checklist in development can be improved for future studies.

CONCLUSION

We reviewed 66 public health research articles that analyzed 1 or more image-sharing social media sites, including Instagram, Pinterest, Tumblr, and Flickr. Of these 66 articles, 59% covered mental health or substance abuse. Data retrieval and sampling methods varied greatly across studies. Gaps remain in understanding how social media users communicate about health-related issues on these image-sharing social media sites. How health care and public health professionals can communicate effectively on such sites deserves further research. ❖

Authors' Contributions

Isaac Chun-Hai Fung, PhD, conceived the research idea, oversaw the entire project, and wrote the first draft of the current version of the manuscript. Elizabeth B Blankenship, MPH, was heavily involved in the writing of the manuscript, before the second and third rounds of literature search. The study was codesigned by Isaac Chun-Hai Fung, PhD, and Elizabeth B Blankenship, MPH. Literature search was performed by Elizabeth B Blankenship, MPH (1st round), and Isaac Chun-Hai Fung, PhD (2nd and 3rd rounds). Literature screening was performed by Elizabeth B Blankenship, MPH, and Isaac Chun-Hai Fung, PhD, in the first and second rounds, and by Isaac Chun-Hai Fung, PhD; Jennifer O Ahweyevu, MPH; Lacey K Cooper, MPH; and Emily A Duncan, MPH, in the third round. For the first round of literature review, Carmen H Duke, MPH, trained Elizabeth B Blankenship, MPH, on the methods of conducting a systematic review. Carmen H Duke, MPH, and Elizabeth B Blankenship, MPH, provided data extraction and quality assessment training to Stacy L Carswell, MPH; Ashley M Jackson, MPH; and Jimmy C Jenkins III, MPH, under Isaac Chun-Hai Fung, PhD's supervision. Elizabeth B Blankenship, MPH, coordinated the review process. Elizabeth B Blankenship, MPH; Stacy L Carswell, MPH; Ashley M Jackson, MPH; and Jimmy C Jenkins III, MPH, screened the papers for inclusion or exclusion, extracted data, and assessed the quality of the included studies. Carmen H Duke, MPH, was the adjudicator if there were disagreements over data extraction. In the second and third rounds of literature review, Isaac Chun-Hai Fung, PhD, trained Jennifer O Ahweyevu, MPH; Lacey K Cooper, MPH; and Emily A Duncan, MPH, in data extraction and quality assessment. Data extraction was performed by Isaac Chun-Hai Fung, PhD; Jennifer O Ahweyevu, MPH; Lacey K Cooper, MPH; and Emily A Duncan, MPH. Quality assessment was performed by Jennifer O Ahweyevu, MPH, and Lacey K Cooper, MPH. Isaac Chun-Hai Fung, PhD, was the adjudicator if there were disagreements over data extraction. Isaac Chun-Hai Fung, PhD, and Jennifer O Ahweyevu, MPH, summarized the data and created the tables. Hai Liang, PhD; King-Wa Fu, PhD; and Zion Tsz Ho Tse, PhD, provided Isaac Chun-Hai Fung, PhD, and Elizabeth B Blankenship, MPH, with intellectual inputs and helped edit the paper. Isaac Chun-Hai Fung, PhD, and Elizabeth B Blankenship,

MPH, serve as co-first authors. Jennifer O Ahweyevu, MPH, and Lacey K Cooper, MPH, serve as co-second authors. Isaac Chun-Hai Fung, PhD, is the corresponding author of the paper and revised the manuscript after peer review.

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