iREVIEW

STATE-OF-THE-ART REVIEW

Cardiovascular Imaging Through the Prism of Modern Metrics

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ABSTRACT

Since its inception in 2008, *JACC: Cardiovascular Imaging (iJACC)* has served as an important publication for all contemporary aspects of cardiovascular imaging. Understanding the dissemination trends in cardiovascular imaging has traditionally been evaluated through citations that assess interest in the research community. Recently, social media, alternative metrics (Altmetrics), and other modern metrics have enabled a more broader understanding of the interests of clinical readership. Through the prism of Altmetrics, this review discusses the most impactful studies across the spectrum of cardiovascular imaging within and outside of *iJACC* during a 3-year period (2017 to 2019). The top 100 Altmetrics *iJACC* articles in this timeframe, included articles with the highest impact with the combination of high Altmetrics (median: 66; interquartile range [IQR]: 56 to 108), high citations (median: 26; IQR: 17 to 34), and high downloads (median: 9,626; IQR: 5,770 to 11,435). This review aims to provide a framework to understand how to incorporate these metrics for a modern approach to dissemination of knowledge in the field of cardiovascular imaging.
(J Am Coll Cardiol Img 2020;13:1256–69)

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the *JACC: Cardiovascular Imaging* author instructions page.

Manuscript received January 31, 2020; revised manuscript received February 28, 2020, accepted March 2, 2020.

ISSN 1936-878X/$36.00 https://doi.org/10.1016/j.jcmg.2020.03.003

"Simplicity is triumphing over complexity, accessibility is beating exclusivity, the power is increasingly in the hands of the user."
—Chandrashekhar and Narula quoting Eric Schmidt of Google (1)

Since its inception in 2008, *JACC: Cardiovascular Imaging (iJACC)* has served as an important publication for all contemporary aspects of cardiovascular imaging. The journal has continually introduced the latest advances in publishing for engaging reader experience. *iJACC* has tried to successfully adapt to the rise of social media (SoMe) for dissemination of cardiovascular imaging knowledge by enabling simplicity, accessibility, and usability via SoMe platforms—reaching viewers beyond traditional online and in-print platforms (**Central Illustration, Figure 1**) (2). This review aims to complement some of the other journal content to demonstrate how SoMe and other modern metrics serve the interests of the readership (3,4). It also provides a framework (**Central Illustration**) to understanding how to incorporate these metrics for dissemination of knowledge in the field of cardiovascular imaging (5).

SOCIAL MEDIA

Traditionally, a key metric of relevance for medical journals has been the power of the Impact Factor, which is a tool that primarily focuses on citation numbers. Because an accurate portrait of citations in published work only emerges after several years, this metric does not represent a full assessment of the early impact on readership (6,7). Thus, the use of Alternative Metrics is an emerging, complementary approach. (2). Termed "Altmetrics," these bibliometrics, as assessed by organizations such as Plum Analytics and Altmetrics.com, allow for measurement of real-time impact of publications through attention to scholarly outputs in nontraditional sources, including news articles, SoMe, and blogs. Through Altmetrics, article dissemination can be tracked, and impact on readership of *iJACC* through shares, retweets, digital impressions, and comments generated. SoMe may also enhance a journal's exposure, create awareness of newly published work, and perhaps most importantly, rapidly communicate this knowledge to the readership.

The Altmetrics Attention Score (AAS) is a metric that measures the total weighted count of the online attention of a published journal article. Some studies have shown that the SoMe promotion strategy is associated with higher readership and downloads, although a 2015 randomized trial showed no effect (8,9). Correlation between the AAS score and citations have been modest but have also been stronger when assessing the early impact of clinical trials or meta-analyses (9,10). The "knowledge chunks" derived from SoMe may further drive post-peer review discussion among the cardiovascular imaging, cardiovascular, and general medical readership within SoMe, which can further propel the publication cycle by generating novel ideas and potentially new collaborations (**Figure 2**).

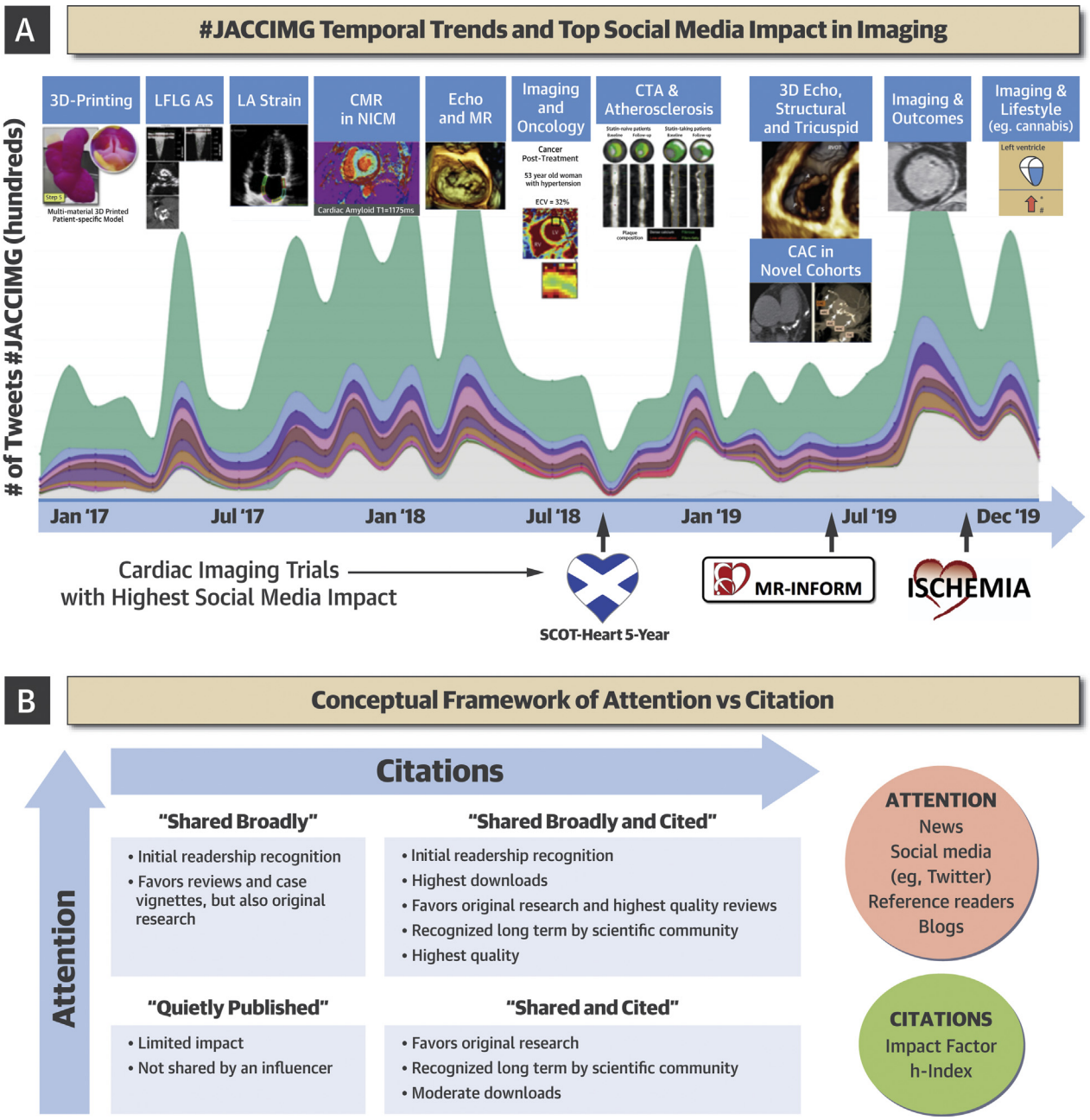
In a detailed review of the top 100 Altmetrics *iJACC* articles over the past 3 years, the SoMe editors of *iJACC* (A.D.C., J.B.G.) qualitatively noted several relevant factors for AAS and citations (**Table 1, Figure 3**). The highest AAS and cited articles have been the publication of the highest quality, novel, prospective clinical studies that are either relevant to daily clinical practice or foundational to further research. Although examining the link between AAS and citations alone from *iJACC* demonstrates low to modest correlation (2), further stratifying highly cited articles into the top and bottom one-half of AAS scores led to several interesting observations (**Table 2**). Of the top 100 Altmetric articles, 40% of these *iJACC* articles were shared directly by the *JACC* SoMe accounts, which to date have >30,000 followers on Twitter and 111,000 followers on Facebook. Another 18% were shared by an individual, Professor M.A. Garcia Fernandez (@MAecocardio) of the Spanish Cardiac Imaging Society, who as of this writing has >10,000 followers on Twitter. Articles are often shared by authors, key opinion leaders, recognized thought leaders in the field, and/or SoMe influencers in a uniquely flattened SoMe hierarchy that allows for interaction across the spectrum of cardiovascular medicine.

However, although a high follower base provides an important means for attention, it alone may not reflect traditional scholarly leadership, defined by metrics such as the H-index or clinical reputation. According to Twitter, high Altmetrics articles were found to have an upper bound reach of followers of >159,000, which resulted from the amplification effect of tweets and retweets (**Table 1**). In addition, early editorial board identification of key advances in the field that led to timely review articles with actionable, novel clinical knowledge both received significant attention and became highly cited. Articles that received both low attention and low citations

ABBREVIATIONS AND ACRONYMS

3D = 3-dimenional
AAS = Altmetrics Attention Score
AS = aortic stenosis
CAC = coronary artery calcium
CAD = coronary artery disease
CMR = cardiac magnetic resonance
FFR = fractional flow reserve
iJACC = ***JACC: Cardiovascular Imaging***
LGE = late gadolinium enhancement
LV = left ventricle
LVEF = left ventricular ejection fraction
PET = positron emission tomography
SoMe = social media

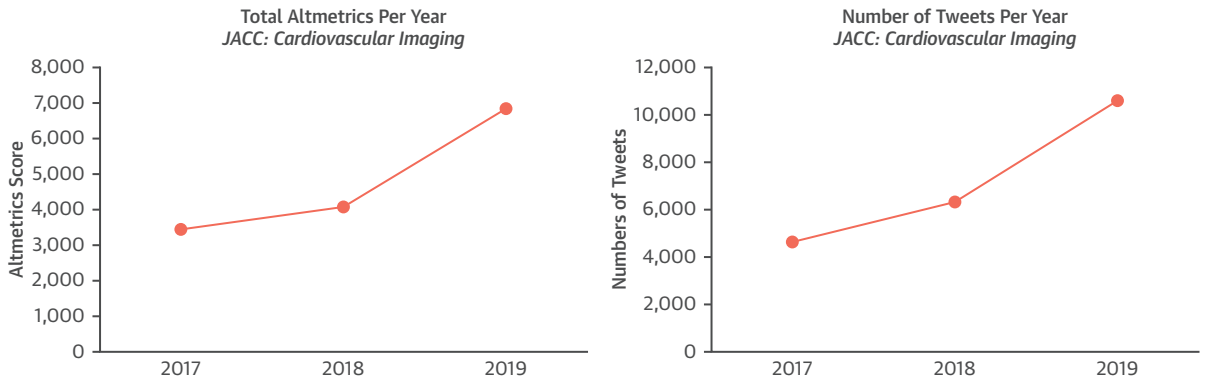
CENTRAL ILLUSTRATION **#JACCIMG Social Media Temporal Trends and a Conceptual Framework of Attention Versus Citations**



Choi, A.D. et al. J Am Coll Cardiol Img. 2020;13(5):1256–69.

(A) Temporal trends in *JACC: Cardiovascular Imaging* (*iJACC*) social media postings on Twitter (#JACCIMG) that include tweets, retweets, and image and article postings from January 2017 through December 2019. **(Top)** Selected high Altmetrics topics from *iJACC* in the time periods. **(Bottom)** Three recent major clinical imaging trials outside of #JACCIMG include the SCOT-HEART, MR-INFORM, and ISCHEMIA trials. Data from Symplur Signals (78). **(B)** Conceptual framework of Altmetrics attention versus citations in cardiovascular (CV) imaging. Articles are categorized as: 1) high-attention, low citation, termed as "shared broadly"; 2) high-attention, high citation, termed as "shared broadly and cited"; 3) low-attention, low citation, termed as "quietly published"; and 4) low attention, high citation, termed as "shared and cited" with general observations included within the figure. 3D = 3-dimensional; AS = aortic stenosis; CAC = coronary artery calcium; CMR = cardiac magnetic resonance; CTA = computed tomography angiography; ECV = extracellular volume; LFLG = low-flow, low gradient; MR = magnetic resonance; NICM = nonischemic cardiomyopathy.

FIGURE 1 **Analysis of Altmetrics Attention Score and Number of Tweets From *iJACC* Articles**



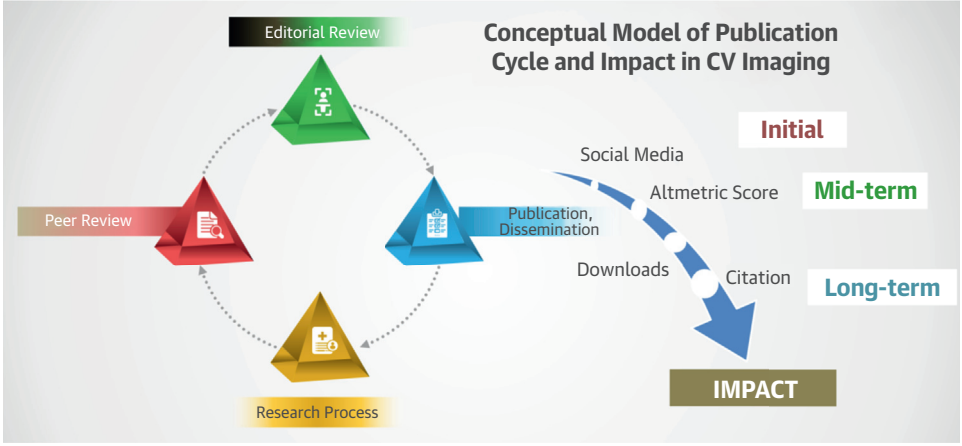
The total Altmetrics score and number of Twitter posts from 2017 to 2019 show steadily rising engagement over this time period. *iJACC* = *JACC: Cardiovascular Imaging.*

were generally less downloaded (Table 1). There was no imaging modality-specific trend identified between high and modest Altmetrics articles.

Thus, in providing a framework of impact of Altmetrics versus citations through all 804 *iJACC* articles from 2017 to 2019, we suggest these 4 general categories: "shared broadly"; "shared broadly and cited"; "shared and cited"; and "quietly published" (Figure 3). The highest-impact articles were those that were both shared broadly and cited, whereas articles shared broadly also demonstrated readership impact.

Determining the long-term scientific merit of high Altmetrics articles bears further analysis (2). For example, the top Altmetrics article in *iJACC* of 2019, an intriguing research letter by Khanji et al. (11) (Altmetrics: 308) evaluated the association between recreational cannabis use and cardiac structure by cardiovascular magnetic resonance (CMR). Here, the investigators found a significantly increased left ventricular volume and impaired strain in cannabis users using data from the United Kingdom Biobank. The Twitter attention was broad, and several major news outlets discussed this letter because of the

FIGURE 2 **Conceptual Model of Publication Cycle and Impact in CV Imaging**



After imaging research, the publication cycle includes peer-review, editorial review, and finally publication. Social media and Altmetrics enable an understanding of the initial (weeks to months) impact of an article, which may have influence on downloads and citations that are measures of impact that become known after months to years. CV = cardiovascular.

TABLE 1 Analysis of Altmetrics Attention Score and Citations From iJACC 2017 to 2019

Altmetrics Top 100 vs. All Other Articles	High Altmetrics, High Citation (n = 29)	High Altmetrics, Low Citation (n = 27)	Moderate Altmetrics High Citation (n = 22)	Moderate Altmetrics Low Citation (n = 22)	All Others (n = 704)
Altmetric score	66 (56–108)	73 (58–90)	36 (33–40)	34 (30–45)	5 (1–14)
Citations	26 (17–34)	4 (3.5–6)	14 (10–29)	3 (1–5)	4 (1–13)
Downloads	9,626 (5,770–11,435)	4,132 (2,363–5,799)	5,524 (3,998–7,382)	1,832 (923–2,302)	493 (272–878)*
Twitter retweets	116 (89–186)	118 (86–142)	52 (40–66)	36 (10–56)	8 (1–29)
Twitter upper bound followers	244,031 (181,654–317,270)	178,807 (118,598 - 270,042)	124,529 (82,842–154,591)	70,392 (28,024–116,399)	N/A
Cardiac imaging subspecialty					
Echocardiography	16 (57)	16 (59)	10 (45)	8 (36)	N/A
Nuclear cardiology	1 (3)	2 (7)	2 (9)	0 (0)	N/A
Cardiac CT	11 (38)	11 (41)	7 (32)	7 (33)	N/A
CMR	6 (21)	12 (44)	5 (23)	3 (14)	N/A
Invasive imaging	1 (4)	1 (4)	5 (23)	3 (14)	N/A
Multimodality	6 (21)	9 (33)	6 (27)	3 (14)	N/A
Study type					
Original research	19 (66)	7 (26)	16 (73)	7 (33)	N/A
Review paper	8 (28)	13 (48)	5 (23)	4 (19)	N/A
Editorial	1 (3)	2 (7)	0 (0)	5 (24)	N/A
Letter/iMail	1 (3)	2 (7)	1 (5)	2 (9)	N/A
Case/iPix	0 (0)	3 (11)	0 (0)	4 (19)	N/A
JACC Journals social media main influencer	11 (39)	6 (22)	14 (64)	7 (33)	N/A

Values are median (interquartile range) and n (%). Papers published in *JACC: Cardiovascular Imaging* (*iJACC*) were stratified into those with the top 100 Altmetric Attention scores versus all other publications. The top 100 Altmetrics papers were then divided into the top and bottom one-half (high altmetrics vs. modest altmetrics) as well as top and bottom one-half of citations (high citation, low citation). Within the top 100 Altmetrics, the generally highest observed downloads were for papers with high altmetrics and high citations. High altmetrics, low citation, and moderate altmetrics, high citation articles had the next highest level of downloads. All others had the lowest range of downloads, were rarely posted on social media, and had generally lower citations. *Downloads data listed through February 2019 for this cell.

CT = computed tomography; CMR = cardiac magnetic resonance.

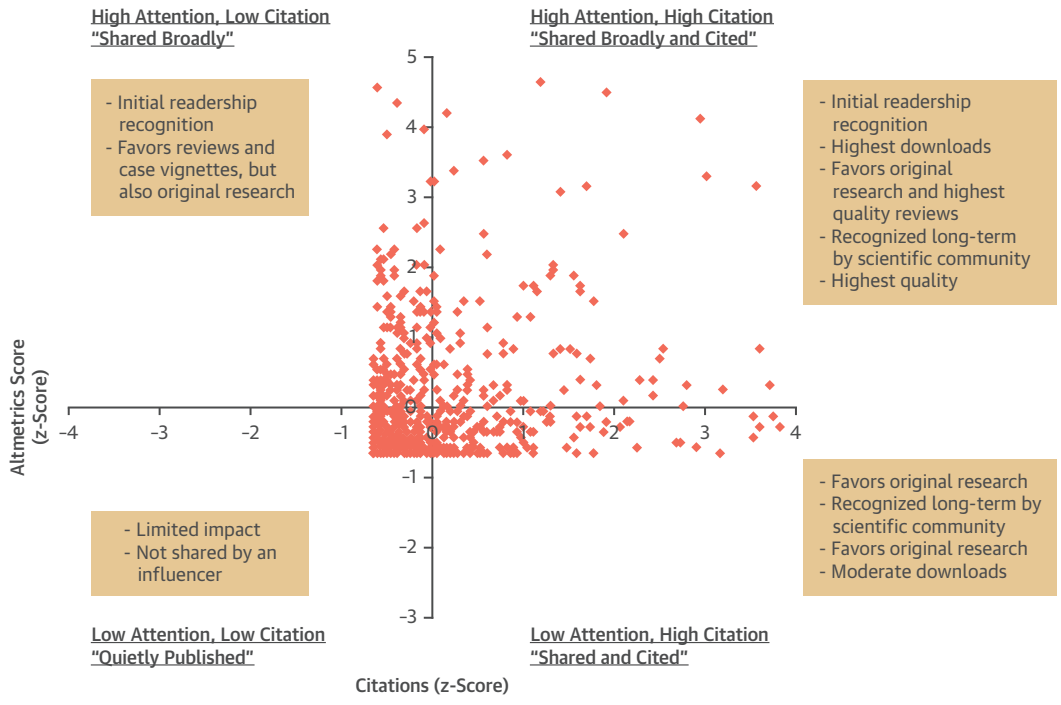
lifestyle-oriented subject matter, giving an alternative portrait of its societal impact. However, limitations of unmeasured confounders, uncertain mechanisms, and long-term prognostic data suggested that the long-term scientific merit was less certain, and therefore, it might receive a lesser degree of citations.

To measure the impact of SoMe in cardiovascular imaging requires evaluating the complementary role of hashtags in tracking the impact of specific topics (Table 2). The hashtag, specifically introduced by the octothorpe symbol (#), is a metadata tag that allows users to search for all posts tagged with that message. Tracking the most relevant SoMe hashtags in imaging reveals tens of millions to hundreds of millions of estimated digital impressions from thousands of global participants online (Table 2).

PROS AND CONS OF SOCIAL MEDIA ENGAGEMENT. There are pros and cons to consider in SoMe engagement in works of demonstrable academic merit. Highly cited articles not disseminated via a SoMe portal have been noted by the *iJACC* editorial team to have less SoMe opportunity for discussion (Figure 3). In a world where many clinical teams are on SoMe to get rapid access to knowledge before print (online before print), this race to the first knowledge of new publications does not completely equate to the impact factor. Nuances of the culture of the SoMe crowd that encompass social and emotional capital may be difficult to quantify but represent an important appreciable factor in knowledge dissemination. SoMe influencers may guide Altmetric trends by discussing publications influenced by an individual's own practice environment, visual appeal, or even simply attention for its own sake. In addition, negative attention to an article may be weighted similarly to positive attention by Altmetrics, making the appropriate scientific merit of a paper confounded. In this vein, online engagement may generate a "boomerang" effect with an unintended and unpredictable response. Negative attention may be unsolicited and lacking appropriate nuance.

With these factors in mind, it raises the question of how *iJACC* should best measure the broad-ranging and valuable "wisdom of the SoMe crowd" (12) with the expertise of a highly experienced editorial board and accomplished peer-review community; these are not mutually exclusive entities. *iJACC,* which is uniquely positioned as an international, trusted hub

FIGURE 3 Conceptual Framework of Altmetrics Versus Citations in CV Imaging



Articles published in *iJACC* (n = 804) from 2017 to 2019 were stratified in a 2 × 2 contingency table with **dots** representing an individual article compared with an article's Altmetrics attention score and number of total citations. A normalized z-score was calculated for each metric. The articles were divided into: 1) high-attention, low citation, termed as "shared broadly"; 2) high-attention, high citation termed as "shared broadly and cited"; 3) low attention, low citation termed as "quietly published"; and 4) low attention, high citation termed as "shared and cited" with general observations included within the Figure. Abbreviations as in Central Illustration.

of cardiac imaging, has a natural interface with the visual-driven aspects of SoMe that enables a high degree of engagement.

HIGH ATTENTION IMAGING ARTICLES ACROSS CARDIOVASCULAR MEDICINE. The studies with the most attention within clinical cardiovascular imaging have evaluated imaging approaches with clinical outcomes in stable coronary artery disease (CAD) (Central Illustration). Because a detailed review of these studies has been discussed within these pages and elsewhere, this review will briefly touch upon the SoMe impact of these studies. The SCOT-Heart (Scottish Computed Tomography of the Heart) 5-year study demonstrated that computed tomography angiography (CTA), in addition to standard care, resulted in significantly reduced death or nonfatal myocardial infarction at 5 years (13). This study was already highly influential according to both traditional metrics (n = 149) and by AAS (Altmetrics: 690). This score was significantly higher than the index paper (Altmetrics: 192) published in the *Lancet* in 2015 (14). Factors for this difference include: 1) increased attention through SoMe; 2) simultaneous SoMe and news coverage at the European Society of Cardiology Congress; and 3) the important positive finding that demonstrated, for the first time, that an imaging strategy showed improved outcomes in a randomized trial.

The tension between Altmetrics attention and scientific merit may be best exemplified in the recent uptick in cardiovascular imaging papers that use machine learning algorithms. A recently published paper that evaluated the radiomic features of adipose tissue fibrosis through the perivascular fat attenuation index from cardiac CTA in the SCOT-Heart trial was found to improve major adverse cardiovascular event(s) prediction beyond traditional risk factors, coronary artery calcium (CAC) score, stenosis, and high-risk plaque features. This *European Heart Journal* publication had an Altmetric score of 853,

TABLE 2 Hashtag Trends in Cardiovascular Imaging Social Media

Hashtag	Hashtag Registration Date*	Total Tweets† (thousands)	Total Retweets (thousands)	Total Participants (thousands)	Digital Impressions‡ (millions)	Visuals§ (thousands)	Papers‖ (thousands)
#JACCIMG	1/1/2017	7.9	7.2	2.5	40.2	7.9	7.7
#ACCImaging	3/30/2017	16.0	13.3	3.3	42.6	14.6	4.8
#EchoFirst	11/20/2017	123.9	105.8	16.1	220.4	116.7	20.1
#CVNuc	8/2/2019	1.4	0.92	0.32	3.1	1.5	0.36
#YesCCT	7/20/2018	21.5	17.4	3.8	62.9	23.7	6.9
#WhyCMR	8/11/2018	28.2	22.7	5.0	65.0	30.8	8.1
#CVImaging	4/1/2016	18.2	14.2	4.2	66.4	16.8	8.1
#ISCHEMIA	10/14/2019	11.0	8.2	4.2	37.4	7.2	2.7

An analysis of tweets, participants, and digital impressions of the most widely-used cardiovascular imaging hashtags. Data from Symplur signals (78). *Registration date reflects the date the hashtag was registered with symplur.com. Individual hashtag data are from the registration date to access on December 31, 2019. †The total number of unique tweets since the hashtag was registered on symplur.com. ‡Impressions are computed by taking the number of times an account has tweeted multiplied by the account's number of followers repeated for all accounts, then finally summed up. §The total number of times each photo, GIF, or video was shared. ‖The total number of papers or links/URLs shared.

fueled by >100 news stories. However, it is uncertain whether this attention reflects rapid broad adoption of this technique, as well as a need for further external validation.

The magnetic resonance perfusion or fractional flow reserve (FFR) in coronary disease (MR-INFORM [The Myocardial Perfusion CMR versus Angiography and FFR to Guide the Management of Patients with Stable Coronary Artery Disease]) study found that use of stress perfusion CMR had a lower incidence of coronary revascularization than FFR, was noninferior to FFR with regard to major adverse events, and generated a significant impact on Twitter (Altmetric: 388).

The ISCHEMIA (International Study of Comparative Health Effectiveness with Medical and Invasive Approaches) trial, which is not yet in fully published form as of this writing, has generated significant interest online after presentation at the recent American Heart Association Scientific Sessions. The hashtag #ISCHEMIA has already generated >30 million digital impressions alone across cardiovascular specialties and general medicine.

Hashtag topics of interest shared broadly should not be ignored. These include: 1) #ThePowerofZero, which is bringing attention to the role of zero CAC imaging for the prediction of cardiovascular events (15–18); 2) #CardsRads, which discusses approaches to cardiology and radiology collaborations in advanced imaging (19); and 3) #Structural and #iEcho, which expand discussions around advocacy, clinical training, and reimbursement issues in this rapidly evolving field (20–22).

From this point forward, to appreciate the interests of the SoMe crowd while allowing the readership to better manage recent advances in the field, this review takes a topical and modality approach to discuss those articles that have garnered both the highest SoMe attention and highest citations over the past 3 years across cardiovascular imaging, with an emphasis on *iJACC*.

ECHOCARDIOGRAPHY

HEART FAILURE. Transthoracic echocardiography offers the ability to assess measures of systolic function, diastolic function, and structural abnormalities (Supplemental Figure 1). Twitter discussion on identification of patients at risk for heart failure elevated the AAS of an investigation by Gong et al. (23) (Altmetrics: 27), which demonstrated that identification of at least 1 abnormal parameter in subjects with preclinical heart failure provided 72% to 82% sensitivity for detection of subsequent progression to overt symptomatic heart failure in subjects age 65 years or older. Echocardiographic epidemiological changes in left ventricular (LV) systolic dysfunction and heart failure within the Framingham Study over 3 decades garnered attention via news media, Twitter, and policy mentions, with a study by Vasan et al. (24) (Altmetric: 62) that noted trends toward lower prevalence of LV systolic dysfunction and increasing frequency of heart failure with preserved ejection fraction (EF). Cardiovascular mortality associated with heart failure with reduced LVEF declined across decades, whereas it remained unchanged for heart failure with preserved LVEF. Defining imaging features of heart failure with preserved LVEF remains a challenge and area of active Twitter discussion.

STRAIN IMAGING. A review of application of 2- and 3-dimensional (3D) strain imaging across cardiac health and disease was the highest Altmetric-rated imaging article during the study period, driven by robust Twitter discussion and a strong Central Illustration in

the study by Morris et al. (25) (Altmetric: 178). Left atrial strain imaging provided unique insights into diastolic dysfunction and might be a better barometer than left atrial size. In patients with elevated LV filling pressures, left atrial strain was more likely to be abnormal than the left atrial volume index (62.4% vs. 33.6%; $p < 0.01$) (26) (Altmetric: 49). Furthermore, left atrial strain might serve to clarify the often convoluted assessment of LV diastolic function, because left atrial strain changes progressively with severity of diastolic function, unlike traditional parameters (27) (Altmetric: 50).

VALVULAR HEART DISEASE. There has been renewed interest in understanding predictors of mortality in asymptomatic severe aortic stenosis (AS). Although an LVEF cutoff of 60% has long been used in AS, new data suggest that an LVEF cutoff of 55% identifies worse outcomes in patients with severe AS and minimal or no symptoms, which sparked discussion on Twitter (28) (Altmetric: 51). Furthermore, a meta-analysis of asymptomatic patients with AS found that impaired global longitudinal strain was predictive of reduced survival in patients with normal LVEFs (29) (Altmetric: 59).

Echocardiographic assessment of ventricular heart disease presents unique difficulties. Traditional echocardiographic parameters may be insufficient for hemodynamic evaluation in the presence of valvular heart disease. In mitral annular calcification, the mitral E/e′ ratio should not be used to estimate LV filling pressures, whereas the mitral E/A ratio and isovolumic relaxation time are useful predictors (30). This research was among the 10 highest AAS studied (Altmetric: 139), driven by a combination of Facebook and Twitter discussions. Evaluation of mitral regurgitation is dependent upon etiology. El Sabbagh et al. (31) (Altmetric: 116) noted that primary and secondary mitral regurgitation represented 2 completely different diseases, with separate natural histories, mechanisms, therapeutic strategies, and outcomes associated with repair. Grayburn et al. (32) (Altmetric: 144) generated attention via news media and Twitter by proposing division of secondary mitral regurgitation into “proportionate” or “disproportionate” on the basis of the ratio of effective regurgitant orifice area and LV end-diastolic volume.

3-DIMENSIONAL ECHOCARDIOGRAPHY. Topics about 3D echocardiography are of high interest on SoMe. Three-dimensional imaging continues to be at the forefront of innovation, spanning improved techniques for chamber quantification, novel cardiac valve visualization, structural planning, 3D printing, and translation to virtual reality (33,34) (Altmetric: 84, Lang et al.). Three-dimensional echocardiography has also helped to clarify paradoxical annular dynamics with systolic expansion and flattening of mitral annular dysfunction in mitral valve prolapse (34).

NUCLEAR CARDIOLOGY AND HEALTH POLICY

NOVEL IMAGING TECHNIQUES. Online discussion and enthusiasm have been substantial for several papers that described novel nuclear imaging techniques. Dweck et al. (35) (Altmetric: 55) conducted a small cohort study that evaluated a hybrid of CMR and positron emission tomography (PET) for diagnosing active sarcoidosis within the myocardium (Supplemental Figure 2). The study evaluated 25 subjects with suspected cardiac sarcoidosis and demonstrated how simultaneous acquisition of the 2 imaging modalities could effectively distinguish patients with active and inactive sarcoidosis, as well as prove absence of cardiac involvement and false-positive PET from insufficient glucose uptake suppression. Online, many retweeted the notice about the article from @JACCJournals and further discussion revolved around cardiologists sharing with one another about the importance of avoiding false-positive diagnoses. Massera et al. (36) (Altmetric: 8) conducted a study in 27 patients with AS that compared 2 software packages for quantifying activity of valve calcification. The methods they applied are being developed as possible outcomes for new pharmacological strategies to reduce progressive calcification of cardiac valves. In addition to discussion on Twitter, this paper was selected for further review on the podcast for the *Journal of Nuclear Cardiology* (37), which regularly has 200 to 300 listeners for each episode.

A well-designed randomized comparative effectiveness study by Patel et al. (38) from September 2019 evaluated the impact of stress myocardial perfusion imaging plus PET versus single-photon emission computed tomography and found no differences in the rate of diagnostic failure, angiography, revascularization, or health status at 1 year, although the study was underpowered. Downstream invasive testing with PET myocardial perfusion imaging was more consistent with high-risk features. The low AAS of 2 masked the importance of this underused study design, underappreciating the multiple advantages of PET myocardial perfusion imaging in myocardial blood flow quantification, and perhaps reflecting bias against negative study results.

PATIENT SAFETY: REDUCING RADIATION. As one of the imaging modalities that uses ionizing radiation, reducing patient radiation exposure is a focus of the nuclear cardiology community. One of the most recent and widely discussed articles on this topic is a review article by Williams et al. (39) (Altmetric: 95). The review summarized important terminology and practical strategies on how physicians and technologists can effectively make imaging safer. The article was discussed on the *Heart* journal podcast (40) and generated numerous tweets from physicians encouraging the conscientious use of imaging with radiation. Thompson et al. (41) (Altmetric: 38) published a research letter in *iJACC* on how their nuclear cardiac laboratory was able to substantially reduce the effective doses received by patients over an 8-year time frame (Supplemental Figure 2). This was accomplished with the acquisition of more efficient cameras, upgrades to software, and redesigned, patient-focused imaging protocols. Although published as a research letter, the high Altmetric score for this paper was driven by news coverage from several outlets, including TCTMD.

HEALTH POLICY. In 2014, the United States government passed a law changing how the Medicare system would reimburse advanced imaging technologies, including nuclear, CT, and CMR, with echocardiography exempt. Since that time, the responsible federal agencies have been working to implement the new system that will require clinicians to reference appropriate use criteria when ordering any noninvasive imaging test. The program has been repeatedly delayed, but the current "go-live" date is January 1, 2021. Because of the many challenges that the program creates for both ordering clinicians and those who provide advanced imaging services, many articles have been written to coach teams on how to be ready for adoption and also asking for additional reprieve and leniency from the government. One such editorial by Doukky et al. (42) (Altmetric: 94) makes the case for collaboration between academic and private practices, observing that efforts to reduce low-value care are a shared responsibility of all physicians and cardiovascular team members.

ATHEROSCLEROSIS, PERFUSION, AND CALCIUM IMAGING BY CARDIAC CT

CARDIAC CTA EVALUATION OF PLAQUE MORPHOLOGY AND PROGRESSION. Developments in CCTA for improved assessment of atherosclerosis, prognostication, and in guiding management developed high interest within the readership (Supplemental Figure 3). A substudy of the PROMISE (Prospective Multicenter Imaging Study for Evaluation of Chest Pain) trial in *JAMA Cardiology* evaluated high-risk plaque features (positive remodeling, low attenuation, or napkin ring sign) and found these features had independent risk prediction among patients with nonobstructive CAD, younger patients, and women (43) (Altmetric: 108). To demonstrate CT use beyond risk prediction to CT evaluation of treatment response, as shared by influencers, @JACCJournals and @jvillacastin, a prospective multinational observational registry, PARADIGM (Progression of AtheRosclerotic PlAque DetermIned by Computed TomoGraphic Angiography Imaging), evaluated patients with suspected or known CAD who underwent serial cardiac CTA (44) (Altmetric: 97). This study divided patients into statin-naïve and statin-taking patients. Through a model of CT quantification, statins were associated with slower progression of noncalcified plaque but increased calcified plaque components (44).

A highly provocative study shared by @JACCJournals and @BinitaShahMD (Altmetric: 143) that evaluated the effects of colchicine and optimal medical therapy on atherosclerotic plaque in patients with recent acute coronary syndrome found significant reductions on serial cardiac CTA in low-attenuation plaque volume and high-sensitivity C-reactive protein. The SoMe response included how this data supported anti-inflammatory strategies (Supplemental Figure 3).

The safety and yield of a selective referral versus direct referral strategy through the CONSERVE (CCTA for Selective Cardiac Catheterization) study received significant SoMe attention from throughout the cardiovascular community (45) (Altmetric: 160). Through a noninferiority study design, a selective referral strategy through cardiac CTA was similarly effective for the diagnosis of CAD, whereas the cardiac CTA strategy reduced invasive catheterization by 77%, with an estimated 57% reduction diagnostic cost.

CAC IMAGING. Deepening understanding of CAC progression through a review of noninvasive, invasive, and histological approaches captured SoMe interest (Supplemental Figure 4) (46) (Altmetrics: 67). CAC was classified as intimal and medial calcification with a specific focus on intimal thickening. The investigators reviewed the effect of sex on atherosclerosis development and the protective effect of estrogen in delaying progression in women. The review also discussed using the subtype of calcium (small, fragmented, spotty) as a better predictor of stable plaque compared with heavy calcium (diffuse, fibrocalcific plaques, sheet of calcium).

A paper by Nakahara et al. (47) (Altmetric: 69) complemented the preceding paper by reviewing the molecular mechanisms belying CAC. Imaging of microcalcification through 18F-NaF discussed in this article led to several subsequent research studies with increasing uptake. To expound further on patients with CAC ≥1,000, a study published by Peng et al. (48), which was presented at the American College of Cardiology 2019 Scientific Sessions, evaluated 66,636 asymptomatic adults from the CAC consortium and found that this phenotype was associated with mortality similar to high-risk secondary prevention cohorts. SoMe coverage of the American College of Cardiology presentation and simultaneous publication in *iJACC* served to elevate the paper to an Altmetric score of 94 (Supplemental Figure 4).

A research letter that evaluated severe CAC in South Asians from the MASALA (Mediators of Atherosclerosis in South Asians Living in America) study was highly shared on SoMe, driven by the large number of news articles (n = 11), particularly from Asian news outlets (49) (Altmetric: 122). In this work, the presence of a family history of heart disease was independently associated with high CAC burden (CAC >300). Finally, a paper by Miname et al. (50) (Altmetric: 86) that evaluated CAC and cardiovascular events in patients with familial hyperlipidemia generated significant SoMe attention. This study demonstrated potential heterogeneity in atherosclerosis manifestation in patients with zero events in the CAC = 0 population and high-risk patients in the CAC >100 population. The SoMe interest was driven in part by discussion around the hashtag #ThePowerofZero.

CARDIOMYOPATHIES, CAD, AND VALVULAR DISEASE BY CMR

CARDIOMYOPATHIES. Myocardial tissue characterization with CMR opened a window to noninvasively assess features of diseased myocardium previously restricted to histology (Supplemental Figure 5). Among the highest attention *iJACC* articles was a paper by Halliday et al. (51) that evaluated the relationship between late gadolinium enhancement (LGE) and dilated cardiomyopathies. When the study stratified LGE into categories of 0% to 2.55%, 2.55% to 5.1%, and >5.1%, the hazard ratios ranged from 2.79 to 4.87 for the 3 groups, with the greatest sudden cardiac death risk in the septum and free wall. A review paper by Patel and Kramer (52) (Altmetric: 75) emphasized the role of CMR in nonischemic cardiomyopathies; in dilated cardiomyopathy, the presence and burden of LGE helped risk stratify for sudden cardiac death (53). The presence of LGE in hypertrophic cardiomyopathy was not enough to prognosticate, but the extent, location, and/or pattern were more important to predict adverse outcomes (54). In sarcoidosis, the presence of LGE had great prognostic value, but could not identify earlier clinical stages, which might be possible by T2 mapping (55). In cardiac amyloidosis, the presence of transmural LGE was associated with >5-fold increase in mortality (56). Both native T1 mapping and extracellular volume fraction were shown to be prognostic in this condition.

By highlighting the value of imaging vignettes on SoMe through cine imaging shared directly to media platforms, Aung et al. (57) (Altmetric: 74) presented 2 cases of LV noncompaction. The first case was the father, who had all the diagnostic features of LV noncompaction by CMR, including a compacted to noncompacted ratio of 4:1, LV dilatation, and global LV systolic dysfunction. The son initially had a hypertrabeculated LV with a ratio of 2.3:1 and preserved LV systolic function. His follow-up showed LV dysfunction, which clarified the noncompaction diagnosis (57).

CAD. Within *iJACC,* the article with the highest attention in the area of CAD and CMR was a study by Dastidar et al. (58) (Altmetric: 114) that evaluated CMR in myocardial infarction with normal coronary arteries (MINOCA). In this case, the Altmetric score was driven by Twitter, with both @JACCJournals and the investigators themselves posting, including senior author Dr. Chiara Bucciarelli-Ducci (@chiarabd). In this cohort of MINOCA (myocardial infarction with normal coronary arteries) patients, 74% had a definitive diagnosis (25% myocarditis, 25% myocardial infarction, and 25% cardiomyopathy) with cardiomyopathy demonstrating the highest mortality followed by those with myocardial infarction. A group from the University of Ulm in Germany presented a randomized clinical trial (n = 200) of patients with symptomatic CAD who underwent direct invasive coronary angiography or stress CMR with adenosine (Supplemental Figure 5) (59) (Altmetric: 32). They found that the CMR group had a lower rate of revascularization versus the rate of the angiography group, without differences in outcomes (59).

VALVULAR HEART DISEASE. In the field of valvular heart disease, CMR offers accurate volumetric and hemodynamic assessments, with myocardial tissue characteristics that give insight on myocardial health. A state-of-the-art review led by Marwick et al. (60) (Altmetric: 50) presented a summary of the data for

assessment of subclinical myocardial dysfunction in AS using echocardiographic and CMR techniques (Supplemental Figure 5). The important prognostic role of LGE and T1 mapping in AS, despite normal LVEF, was established (61,62). The currently most studied CMR parameter in AS has been LGE, which has been consistently prognostic (63). This area of research holds promise for CMR tissue characterization becoming part of the assessment and decision-making of asymptomatic severe AS.

CARDIO-ONCOLOGY

Cardio-oncology clinical studies allow insight with regard to cardiovascular outcomes in cancer patients as influenced by risk factors, associated procedures, additional diagnoses, and current real-life clinical practices (64–66). For example, the CECCY (Carvedilol for Prevention of Chemotherapy-Related Cardiotoxicity) trial found a low incidence (1% in the placebo group) of LV systolic dysfunction in a cohort of 200 patients with breast cancer who received treatment with anthracycline and who were randomized to either preventive treatment with carvedilol or placebo (67).

Beyond monitoring cardiotoxicity of anthracycline and trastuzumab toxicity, a state-of-the-art paper on multimodality imaging in oncology patients by Plana et al. (68) (Altmetric: 48) emphasized not only the role of echocardiography and strain to identify cardiotoxicity, but how other modalities might contribute significantly to the assessment of different clinical scenarios in patients with cancer. Cardiac CTA, nuclear stress modalities, and stress CMR can help identify significant CAD in patients undergoing cancer treatments that may cause ischemia (e.g., 5-fluoracil, capecitabine, bevacizumab, sorafenib, and sunitinib) (69). CMR tissue characterization has helped understanding of certain mechanistic aspects of chemotherapy-related cardiotoxicity, such as development of myocardial inflammation earlier and fibrosis later, but applications are still in the realm of research. Jordan et al. (70) (Altmetric: 80) presented a practical clinical review (Supplemental Figure 5) on the use of CMR in cardio-oncology.

STRUCTURAL HEART INTERVENTIONAL IMAGING

The field of structural heart interventional imaging has benefitted from SoMe, a forum that fills a critical need for rapid dissemination of knowledge in a dynamically changing field. SoMe has served not only to bring attention to the papers published, but also as a tool to advance and bridge knowledge gaps among barriers to access to care, new devices, and new imaging training platforms for all. Because of the broad published reports within structural interventional imaging, several review articles have had the highest Altmetrics impact. Because most clinical centers have limited access to first-in-man or novel clinical trial devices, a state-of-the art paper by Hahn et al. (71) on the critical metrics guiding imaging know-how and requirements for investigational tricuspid annuloplasty devices (Trialign [Mitralign, Tewksbury, Massachusetts] and Cardioband [Edwards Lifesciences, Irvine, California]), leaflet devices (edge-to-edge and FORMA [Edwards Lifesciences, Irvine, California]), and transcatheter tricuspid valve replacements reached an Altmetrics score of 61 (Supplemental Figure 6). SoMe discussions on tricuspid interventions have triggered a new hashtag #TreatTR. Moving from the tricuspid valve to mitral valve, articles on methods and efficacy (72) (Altmetric: 76), patient selection, and periprocedural guidance (73) (Altmetric: 42) have been shared broadly.

Contrary to traditional academic publications, step-by-step tutorials and user guides are now leading the impact both clinically and by Altmetrics in structural interventional imaging. Bax et al. (74) illustrated the multimodality critical thinking required for transcatheter mitral repair and replacement approaches across various devices in their recent publication (Supplemental Figure 6). This review included devices focused on the leaflets (e.g., MitraClip [Abbott Laboratories, Abbott Park, Illinois]), annulus (e.g., Cardioband), and replacement (e.g., Intrepid TMVR [Medtronic, Minneapolis, Minnesota]).

Much of the role of imaging in transcatheter interventions is not only prevention of procedural complications, but in identification of challenging cases while also troubleshooting device success and failure. Pibarot et al. (74) (Altmetric: 71) demonstrated the role of multimodality thinking in providing accurate differential diagnosis for clinical teams troubleshooting symptoms of dyspnea in patients after aortic valve replacement (Supplemental Figure 6) and the role of having access to multiple imaging toolkits. A multimodality review of imaging for evaluation of the left atrial appendage presented an up-to-date complementary approach to planning and treatment of atrial fibrillation and appendage occlusion (75) (Altmetric: 52).

The value of structural heart interventional imaging providers in the success of transcatheter interventions has commonly been undervalued. A letter to the editor by Wang et al. (20) (Altmetric: 47) outlining the need for training and challenges in a career in structural imaging was accompanied by robust

SoMe discussions. Subsequent *iJACC*-commissioned editorial viewpoints on core competencies in cardiac CT (21) (Altmetric: 29) and transesophageal echocardiography in structural imaging (22) (Altmetric: 29) sparked ongoing efforts within the cardiovascular societies.

The future of structural heart interventional imaging is based on adaptation of new technology toolkits to enhance and improve existing clinical paradigms. A state-of-the art review by Vukicevic et al. (76) (Altmetric: 104) on cardiac 3D printing and its future directions was followed by original research by Qian et al. (77) (Altmetric: 203) on the application of 3D printing procedural simulation in predicting paravalvular leak after transcatheter aortic valve replacement. These papers consisted of new conceptual frameworks for novel technologies not common to modern clinical practice, with case examples demonstrating images in interventional planning and a multimodal approach to application of 3D printing in transcatheter interventions (76).

CONCLUSIONS: FUTURE OF SOCIAL MEDIA AND CARDIOVASCULAR IMAGING

Rather than seeking solely to answer or refute the question of post hoc ergo propter hoc between Altmetrics and citations, understanding the emergence of SoMe in cardiovascular imaging necessitates keeping the mission of *iJACC* at the core: the dissemination of novel advancement in imaging for the cardiovascular community. In 2018, *iJACC* made the conscious decision to become an online only journal, because 90% of the readership access content through online devices. Because digital media are at the vanguard of publishing, particularly in imaging, modern media, including SoMe, is a natural part of this evolutionary arc. At the same time, *iJACC* remains committed to serving as an avenue for novel, highest-quality, peer-reviewed papers. Because the impact factor remains a "curious and capricious metric" for the journal (5), the emergence of Altmetrics, SoMe shares, and hashtag impressions provide an evolving portrait of the readership. What is trending on SoMe may not always become scientifically impactful by citations (and not absent its own inherent risks and challenges; "moth to the flame?") (2). Yet, assessing trends (**Central Illustration**) while keeping aim on lasting impact are not mutually exclusive but complementary goals. It is the goal of the authors of this paper that the conceptual framework (**Central Illustration, Figure 2**) presented may serve as a starting point for the cardiovascular community to best integrate these evolving measures of attention and citation. Lastly, *iJACC* aims to further tap into the unreached potential of SoMe to accelerate the translation of this research to global audiences. Join us by following the hashtag #JACCIMG in this digital (r)evolution!

HIGHLIGHTS

- Understanding the relationship of the impact in cardiovascular imaging papers requires the incorporation of Altmetrics, SoMe, and citation impact to assess for the early effects on readership.
- This review provides a framework to understand how these metrics enable knowledge dissemination through a discussion of the top topics across the field of cardiovascular imaging from 2017 to 2019.
- This novel framework of Altmetrics, SoMe, and citations may allow the cardiovascular community to further tap into the unreached potential of SoMe to accelerate the translation of future research to global audiences.

ACKNOWLEDGMENT The authors thank Dr. Vishak Kumar for his initial review of the SoMe aspects of the Altmetrics data.

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REFERENCES

1. Chandrashekhar Y, Narula J. iJACC in the evolving world of integrated imaging: a spectator, a follower, or a trail blazer. J Am Coll Cardiol Img 2008;1:691–3.

2. Chandrashekhar Y, Shaw L. Journal editors and altmetrics: moth to the flame? J Am Coll Cardiol Img 2019;12:1899–902.

3. Shaw L, Chandrashekhar Y, JACC: Cardiovascular Imaging Editors. Progress in cardiovascular imaging. J Am Coll Cardiol Img 2019;12:2589–610.

4. Kramer CK, Shaw LJ, Chandrashekhar Y, JACC: Cardiovascular Imaging Editors. Progress in cardiovascular imaging. J Am Coll Cardiol Img 2018;11:1883–914.

5. Parwani P, Choi AD, Lopez-Mattei J, et al. Understanding social media: opportunities for cardiovascular medicine. J Am Coll Cardiol 2019;73:1089–93.

6. Fuster V. Impact factor: a curious and capricious metric. J Am Coll Cardiol 2017;70:1530–1.

7. Choi AD, Feuchtner GM, Weir-McCall J, Shaw LJ, Min JK, Villines TC. Accelerating the future of cardiac CT: social media as sine qua non? J Cardiovasc Comput Tomogr 2020 Jan 31 [E-pub ahead of print].

8. Fox CS, Bonaca MA, Ryan JJ, Massaro JM, Barry K, Loscalzo J. A randomized trial of social media from Circulation. Circulation 2015;131:28–33.

9. Widmer RJ, Mandrekar J, Ward A, et al. Effect of promotion via social media on access of articles in an academic medical journal: a randomized controlled trial. Acad Med 2019;94:1546–53.

10. Barakat AF, Nimri N, Shokr M, et al. Correlation of Altmetric Attention Score with article citations in cardiovascular research. J Am Coll Cardiol 2018;72:952–3.

11. Khanji MY, Jensen MT, Kenawy AA, et al. Association between recreational cannabis use and cardiac structure and function. J Am Coll Cardiol Img 2020;13:886–8.

12. Yeh RW. Academic cardiology and social media: navigating the wisdom and madness of the crowd. Circ Cardiovasc Qual Outcomes 2018;11:e004736.

13. SCOT-Heart Investigators, Newby DE, Adamson PD, et al. Coronary CT angiography and 5-year risk of myocardial infarction. N Engl J Med 2018;379:924–33.

14. SCOT-Heart Investigators. CT coronary angiography in patients with suspected angina due to coronary heart disease (SCOT-HEART): an open-label, parallel-group, multicentre trial. Lancet 2015;385:2383–91.

15. Mitchell JD, Fergestrom N, Gage BF, et al. Impact of statins on cardiovascular outcomes following coronary artery calcium scoring. J Am Coll Cardiol 2018;72:3233–42.

16. Mitchell JD, Paisley R, Moon P, Novak E, Villines TC. Coronary artery calcium and long-term risk of death, myocardial infarction, and stroke: the Walter Reed Cohort Study. J Am Coll Cardiol Img 2018;11:1799–806.

17. Mszar R, Grandhi GR, Valero-Elizondo J, et al. Absence of coronary artery calcification in middle aged familial hypercholesterolemia patients without atherosclerotic cardiovascular disease. J Am Coll Cardiol Img 2019;13:1090–2.

18. Nasir K. Message for 2018 cholesterol management guidelines update: time to accept the power of zero. J Am Coll Cardiol 2018;72:3243–5.

19. Parwani P, Lopez-Mattei J, Choi AD. Building bridges in cardiology and radiology: why collaboration is the future of cardiovascular imaging. J Am Coll Cardiol Img 2018;11:1713–7.

20. Wang DD, Geske J, Choi AD, et al. Navigating a career in structural heart disease interventional imaging. J Am Coll Cardiol Img 2018;11:1928–30.

21. Leipsic J, Norgaard BL, Khalique O, et al. Core competencies in cardiac CT for imaging structural heart disease interventions: an expert consensus statement. J Am Coll Cardiol Img 2019;12:2555–9.

22. Hahn RT, Mahmood F, Kodali S, et al. Core competencies in echocardiography for imaging structural heart disease interventions: an expert consensus statement. J Am Coll Cardiol Img 2019;12:2560–70.

23. Gong FF, Campbell DJ, Prior DL. Noninvasive cardiac imaging and the prediction of heart failure progression in preclinical stage A/B subjects. J Am Coll Cardiol Img 2017;10:1504–19.

24. Vasan RS, Xanthakis V, Lyass A, et al. Epidemiology of left ventricular systolic dysfunction and heart failure in the Framingham Study: an echocardiographic study over 3 decades. J Am Coll Cardiol Img 2018;11:1–11.

25. Voigt JU, Cvijic M. 2- and 3-dimensional myocardial strain in cardiac health and disease. J Am Coll Cardiol Img 2019;12:1849–63.

26. Morris DA, Belyavskiy E, Aravind-Kumar R, et al. Potential usefulness and clinical relevance of adding left atrial strain to left atrial volume index in the detection of left ventricular diastolic dysfunction. J Am Coll Cardiol Img 2018;11:1405–15.

27. Singh A, Addetia K, Maffessanti F, Mor-Avi V, Lang RM. LA strain for categorization of LV diastolic dysfunction. J Am Coll Cardiol Img 2017;10:735–43.

28. Bohbot Y, de Meester de Ravenstein C, Chadha G, et al. Relationship between left ventricular ejection fraction and mortality in asymptomatic and minimally symptomatic patients with severe aortic stenosis. J Am Coll Cardiol Img 2019;12:38–48.

29. Magne J, Cosyns B, Popescu BA, et al. Distribution and prognostic significance of left ventricular global longitudinal strain in asymptomatic significant aortic stenosis: an individual participant data meta-analysis. J Am Coll Cardiol Img 2019;12:84–92.

30. Abudiab MM, Chebrolu LH, Schutt RC, Nagueh SF, Zoghbi WA. Doppler echocardiography for the estimation of LV filling pressure in patients with mitral annular calcification. J Am Coll Cardiol Img 2017;10:1411–20.

31. El Sabbagh A, Reddy YNV, Nishimura RA. Mitral valve regurgitation in the contemporary era: insights into diagnosis, management, and future directions. J Am Coll Cardiol Img 2018;11:628–43.

32. Grayburn PA, Sannino A, Packer M. Proportionate and disproportionate functional mitral regurgitation: a new conceptual framework that reconciles the results of the MITRA-FR and COAPT trials. J Am Coll Cardiol Img 2019;12:353–62.

33. Lang RM, Addetia K, Narang A, Mor-Avi V. 3-dimensional echocardiography: latest developments and future directions. J Am Coll Cardiol Img 2018;11:1854–78.

34. Lee AP, Jin CN, Fan Y, Wong RHL, Underwood MJ, Wan S. Functional implication of mitral annular disjunction in mitral valve prolapse: a quantitative dynamic 3D echocardiographic study. J Am Coll Cardiol Img 2017;10:1424–33.

35. Dweck MR, Abgral R, Trivieri MG, et al. Hybrid magnetic resonance imaging and positron emission tomography with fluorodeoxyglucose to diagnose active cardiac sarcoidosis. J Am Coll Cardiol Img 2018;11:94–107.

36. Massera D, Doris MK, Cadet S, et al. Analytical quantification of aortic valve 18F-sodium fluoride PET uptake. J Nucl Cardiol 2018 Nov 29 [E-pub ahead of print].

37. Journal of Nuclear Cardiology Podcast. Available at: https://soundcloud.com/jnc-podcast/garcia-slomka-analytical-quantification-of-aortic-valve-18f-sodium-fluoride-pet-uptake. Accessed January 4, 2020.

38. Patel KK, Al Badarin F, Chan PS, et al. Randomized comparison of clinical effectiveness of pharmacologic SPECT and PET MPI in symptomatic CAD patients. J Am Coll Cardiol Img 2019;12:1821–31.

39. Williams M, Stewart C, Weir NW, Newby DE. Using radiation safely in cardiology: what imagers need to know. Heart 2019;105:10.

40. Heart BMJ Podcast. Radiation – what cardiologists need to know. Available at: https://soundcloud.com/bmjpodcasts/radiation-what-we-need-to-know. Accessed January 4, 2020.

41. Thompson RC, O'Keefe JH, McGhie AI, Bybee KA, Thompson EC, Bateman TM. Reduction of SPECT MPI radiation dose using contemporary protocols and technology. J Am Coll Cardiol Img 2018;11:282–3.

42. Doukky R, Diemer G, Medina A, et al. Promoting appropriate use of cardiac imaging: no longer an academic exercise. Ann Intern Med 2017;166:438–40.

43. Ferencik M, Mayrhofer T, Bittner DO, et al. Use of high-risk coronary atherosclerotic plaque detection for risk stratification of patients with stable chest pain: a secondary analysis of the PROMISE randomized clinical trial. JAMA Cardiol 2018;3:144–52.

44. Lee SE, Chang HJ, Sung JM, et al. Effects of statins on coronary atherosclerotic plaques: the PARADIGM study. J Am Coll Cardiol Img 2018;11:1475–84.

45. Chang HJ, Lin FY, Gebow D, et al. Selective referral using CCTA versus direct referral for individuals referred to invasive coronary angiography for suspected CAD: a randomized, controlled, open-label trial. J Am Coll Cardiol Img 2019;12:1303–12.

46. Mori H, Torii S, Kutyna M, Sakamoto A, Finn AV, Virmani R. Coronary artery calcification and its progression: what does it really mean? J Am Coll Cardiol Img 2018;11:127–42.

47. Nakahara T, Dweck MR, Narula N, Pisapia D, Narula J, Strauss HW. Coronary artery calcification: from mechanism to molecular imaging. J Am Coll Cardiol Img 2017;10:582–93.

48. Peng AW, Mirbolouk M, Orimoloye OA, et al. Long-term all-cause and cause-specific mortality in asymptomatic patients with CAC ≥1,000: results from the CAC Consortium. J Am Coll Cardiol Img 2020;13:83–93.

49. Patel J, Al Rifai M, Cainzos-Achirica M, et al. Family history of CHD is associated with severe CAC in South Asians: comparing the MASALA and MESA studies. J Am Coll Cardiol Img 2017;10:958–60.

50. Miname MH, Bittencourt MS, Moraes SR, et al. Coronary artery calcium and cardiovascular events in patients with familial hypercholesterolemia

receiving standard lipid-lowering therapy. J Am Coll Cardiol Img 2019;12:1797–804.

51. Halliday BP, Baksi AJ, Gulati A, et al. Outcome in dilated cardiomyopathy related to the extent, location, and pattern of late gadolinium enhancement. J Am Coll Cardiol Img 2019;12:1645–55.

52. Patel AR, Kramer CM. Role of cardiac magnetic resonance in the diagnosis and prognosis of nonischemic cardiomyopathy. J Am Coll Cardiol Img 2017;10:1180–93.

53. Gulati A, Jabbour A, Ismail TF, et al. Association of fibrosis with mortality and sudden cardiac death in patients with nonischemic dilated cardiomyopathy. JAMA 2013;309:896–908.

54. Chan RH, Maron BJ, Olivotto I, et al. Prognostic value of quantitative contrast-enhanced cardiovascular magnetic resonance for the evaluation of sudden death risk in patients with hypertrophic cardiomyopathy. Circulation 2014;130:484–95.

55. Crouser ED, Ono C, Tran T, He X, Raman SV. Improved detection of cardiac sarcoidosis using magnetic resonance with myocardial T2 mapping. Am J Respiratory Critical Care Med 2014;189:109–12.

56. Fontana M, Pica S, Reant P, et al. Prognostic value of late gadolinium enhancement cardiovascular magnetic resonance in cardiac amyloidosis. Circulation 2015;132:1570–9.

57. Aung N, Zemrak F, Mohiddin SA, Petersen SE. LV Noncompaction cardiomyopathy or just a lot of trabeculations? J Am Coll Cardiol Img 2017;10:704–7.

58. Dastidar AG, Baritussio A, De Garate E, et al. Prognostic role of CMR and conventional risk factors in myocardial infarction with nonobstructed coronary arteries. J Am Coll Cardiol Img 2019;12:1973–82.

59. Buckert D, Witzel S, Steinacker JM, Rottbauer W, Bernhardt P. Comparing cardiac magnetic resonance–guided versus angiography-guided treatment of patients with stable coronary artery disease: results from a prospective randomized controlled trial. J Am Coll Cardiol Img 2018;11:987–96.

60. Dahl JS, Magne J, Pellikka PA, Donal E, Marwick TH. Assessment of subclinical left ventricular dysfunction in aortic stenosis. J Am Coll Cardiol Img 2019;12:163–71.

61. Barone-Rochette G, Piérard S, De Meester De Ravenstein C, et al. Prognostic significance of LGE by CMR in aortic stenosis patients undergoing valve replacement. J Am Coll Cardiol 2014;64:144–54.

62. Dweck MR, Joshi S, Murigu T, et al. Midwall fibrosis is an independent predictor of mortality in patients with aortic stenosis. J Am Coll Cardiol 2011;58:1271–9.

63. Bing R, Cavalcante JL, Everett RJ, Clavel M-A, Newby DE, Dweck MR. Imaging and impact of myocardial fibrosis in aortic stenosis. J Am Coll Cardiol Img 2019;12:283–96.

64. Potts JE, Iliescu CA, Lopez Mattei JC, et al. Percutaneous coronary intervention in cancer patients: a report of the prevalence and outcomes in the United States. Eur Heart J 2019;40:1790–800.

65. Bharadwaj A, Potts J, Mohamed MO, et al. Acute myocardial infarction treatments and outcomes in 6.5 million patients with a current or historical diagnosis of cancer in the USA. Eur Heart J 2019 Dec 4 [E-pub ahead of print].

66. Guha A, Buck B, Biersmith M, et al. Contemporary impacts of a cancer diagnosis on survival following in-hospital cardiac arrest. Resuscitation 2019;142:30–7.

67. Avila MS, Ayub-Ferreira SM, de Barros Wanderley MR, et al. Carvedilol for prevention of chemotherapy-related cardiotoxicity: the CECCY Trial. J Am Coll Cardiol 2018;71:2281–90.

68. Plana JC, Thavendiranathan P, Bucciarelli-Ducci C, Lancellotti P. Multi-modality imaging in the assessment of cardiovascular toxicity in the cancer patient. J Am Coll Cardiol Img 2018;11:1173–86.

69. Hassan SA, Palaskas N, Kim P, et al. Chemotherapeutic agents and the risk of ischemia and arterial thrombosis. Curr Atheroscler Rep 2018;20:10.

70. Jordan JH, Todd RM, Vasu S, Hundley WG. Cardiovascular magnetic resonance in the oncology patient. J Am Coll Cardiol Img 2018;11:1150–72.

71. Hahn RT, Nabauer M, Zuber M, et al. Intraprocedural imaging of transcatheter tricuspid valve interventions. J Am Coll Cardiol Img 2019;12:532–53.

72. Bax JJ, Debonnaire P, Lancellotti P, et al. Transcatheter interventions for mitral regurgitation: multimodality imaging for patient selection and procedural guidance. J Am Coll Cardiol Img 2019;12:2029–48.

73. Wunderlich NC, Beigel R, Ho SY, et al. Imaging for mitral interventions: methods and efficacy. J Am Coll Cardiol Img 2018;11:872–901.

74. Pibarot P, Magne J, Leipsic J, et al. Imaging for predicting and assessing prosthesis-patient mismatch after aortic valve replacement. J Am Coll Cardiol Img 2019;12:149–62.

75. Pathan F, Hecht H, Narula J, Marwick TH. Roles of transesophageal echocardiography and cardiac computed tomography for evaluation of left atrial thrombus and associated pathology: a review and critical analysis. J Am Coll Cardiol Img 2018;11:616–27.

76. Vukicevic M, Mosadegh B, Min JK, Little SH. Cardiac 3D printing and its future directions. J Am Coll Cardiol Img 2017;10:171–84.

77. Qian Z, Wang K, Liu S, et al. Quantitative prediction of paravalvular leak in transcatheter aortic valve replacement based on tissue-mimicking 3D printing. J Am Coll Cardiol Img 2017;10:719–31.

78. Symplur Signals. Available at: https://www.symplur.com. Accessed January 4, 2020.

KEY WORDS Altmetrics, cardiac computed tomography, cardiac magnetic resonance, echocardiography, interventional cardiology, medical publishing, nuclear cardiology, social media, structural

APPENDIX For supplemental figures, please see the online version of this paper.