Advanced Therapies in Medicine and its diffusion in the online mass media: a bibliometric analysis of Tissue Engineering.

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Abstract

Tissue engineering (TE) constitutes a multidisciplinary scientific discipline focused on the construction of artificial tissues to regenerate end-stage organs. The impact of TE has led to a clinical revolution since novel therapies are available to attend several conditions. In this sense, its onset has supposed the communication of innovative discoveries in the age of social and mass media. This study aims to evaluate the global online dimension of TE from 2012 to 2018 by using data from the Web of Science (WoS) and Altmetrics. We have analysed 23,719 documents through descriptive and statistical methodologies. First, the descriptive analysis showed the evolution of TE original articles in five online platforms (Twitter, Patents, Facebook, Mendeley readers and News) and compared the most relevant TE documents ranked by their traditional and alternative metrics of impact. Secondly, we carried out a correlation and factorial analysis and then constructed a linear regression model to define a mathematical equation for the prediction of future TE citations counts from Altmetric scores. The obtained results suggest a growing presence of TE in the online social web and the feasibility in the context of global science to anticipate TE traditional academic impact by using social media

Keywords

Advanced Therapies; Online Mass Media; Tissue Engineering; Bibliometrics; Communication of Science

Introduction

Tissue Engineering (TE) is a multidisciplinary discipline aiming to develop biological substitutes that can restore, maintain, or even improve the structure or functionality of damaged tissues (Langer & Vacanti, 1993). Since its appearance in 1988 (Viola, Bal, & Grad, 2003), TE has globally spread to improve current therapeutic approaches entailing a revolution in health sciences (Kaul & Ventikos, 2015). In this sense, several TE devices have been employed in the treatment of damaged blood vessels (Kumar, Brewster, Caves, & Chaikof, 2011), peripheral nerve injuries (Carriel, Alaminos, Garzon, Campos, & Cornelissen, 2014), chronic skin ulcerations (Debels, Hamdi, Abberton, & Morrison, 2015) , oral mucosal replacement (Martín-Piedra et al., 2016; Sanchez-Quevedo et al., 2007) and corneal lesions (Rico-Sánchez et al., 2019).

This growing interest in TE research has been demonstrated through the increasing number of TE documents, such as the recent literature states (Santisteban-Espejo et al., 2018). Besides, in order to identify TE global trends and to define the cognitive and social framework that undergoes TE scientific evolution,

several analyses have also been performed (Santisteban-Espejo et al., 2019). These bibliometric-based studies can help administrative authorities to better plan funding allocations and to promote synergies within TE scientific community, as previously stated in other scientific areas (Abramo, D'Angelo, & Caprasecca, 2009).

In this context, traditional bibliometric analysis has used the information extracted from academic documents (i.e. citations or keywords) in order to understand the development of TE area (Dai G, 2000; Santisteban-Espejo et al., 2019; Santisteban-Espejo et al., 2018). Nevertheless, these classical bibliometric methods have been criticized in recent years because their fewer adequacy to comprehend the real online attention of scientific research. As a consequence, alternative metrics, formerly called Altmetrics, have been developed to evaluate scientific behaviour through information content at social media (Priem, Piwowar, & Hemminger, 2011).

This altmetric methodology describes a web-based metric for the impact of publications and other scholarly material by using data from social media platforms (i.e.Twitter, Facebook, Google+, blogs, Mendeley, CiteULike, Reddit and Wikipedia, among others) (Veeranjaneyulu, 2017). The appearance of this type of measures is related to the social media revolution; there are now different groups of the population, non-author professionals, which read research articles and now also share them and, furthermore, new types of academic outputs have appeared (Moral-Munoz & Cobo, 2018).

Consequently, the traditional acceptance that the research output only was disseminated within the scientific community has now changed. In addition, the online public nature of these alternative tools permits to track mentions of scholarly articles across the online landscape faster and broader than traditional citation metrics (Verma, 2018). The impact of the Altmetrics and its complementary role in association with traditional bibliometrics have been well stated in several disciplines (Haustein, Bowman, & Costas, 2016).

In this context of global science, where information is shared in the social web, even previously to its communication within the academic community, it would be interesting to analyse the real scientific impact of TE in our society. To our knowledge, no documents are currently available evaluating this aspect in TE research field. Therefore, the primary aim of this study is to determine the online dimension of TE scientific production in social media and to correlate it with traditional scholarly impact. Then, we perform a factorial analysis to identify the components that could explain the correlation results and, finally, we developed a prediction equation for future TE citations based on altmetrics data.

Materials and methods

Sample

The metadata used in this study were obtained from the Web of Science (WoS) Core Collection bibliographic database. In this sense, WoS is considered one of the most relevant scientific information sources as it contents reliable evidence about citations, and it is widely used in research evaluations (Bakkalbasi, Bauer, Glover, & Wang, 2006).

The search strategy used in this study was "TISSUE ENGINEER*" or "TISSUE-ENGINEER*', and it was applied on Science Citation Index (SCI) - Expanded Collection for a period between 2012 and 2018. Once the metadata was extracted, we excluded reviews, book chapters, meeting abstracts, and proceeding articles. Then, original articles obtained from this research were matched with the information available at the Altmetrics web (www.altmetric.com). It holds important social data since 2012 from a much broader sources spectrum than traditional metrics (e.g. web-based references, news media mentions, Twitter mentions or patents, among others) (Trueger et al., 2015).

Descriptive analysis

In order to comprehend TE behaviour in the social web and to compare it with traditional TE scholarly dimension, we carried out two different analysis. First, we studied the presence of TE original articles in seven different research outputs (WoS, Altmetric Attention Score, Twitter, Patents, Facebook, Mendeley readers and News) as the percentage of documents with at least one mention or a citation from 2012 to 2018.

Following Eysenbach, in the case of Twitter, we called a mention on it a*twettation* meaning the mention of a TE journal article URL, retweet of the same tweet or sending a modified tweet by other users (Eysenbach, 2011). Secondly, the Top 10 most cited TE original articles from 2012 to 2018 were ranked by their number of WoS citations and the Altmetric Attention score as a bibliometric measure of online attention (Trueger et al., 2015).

Statistical analysis

Due to the appearance of novel social platforms where TE research is shared, we have also performed a statistical analysis including three different tests: Spearman correlation test (Asuero, Sayago, & Gonzalez, 2006), factorial analysis (Taherdoost, Sahibuddin, & Jalaliyoon, 2014) and linear regression model (M. Thelwall & Wilson, 2014). In this sense, the collection of cites using traditional metrics requires several years and the availability of data provided by Almetrics.com before 2015 is not extensive due to the platform was founded in 2012. Thus, the correlation and factorial studies were performed for 2015 metadata. This strategy has been employed in other scientific disciplines (Mike Thelwall & Nevill, 2018). Furthermore, all citation and mention counts were transformed with the formula Ln(1+x) before processing to reduce skewing (Mike Thelwall & Nevill, 2018).

First, the Kolmogorov-Smirnov test was calculated to verify the dataset do not follow a normal distribution for the next 16 variables that overall characterize TE online dimension: 1) WoS citations 2) News, 3) Blogs, 4) Policy, 5) Twitter, 6) Patents, 7) Peer review, 8) Weibo, 9) Facebook, 10) Wikipedia, 11) Google, 12) Reddit, 13) F1000, 14) Q&A, 15) Video and 16) Mendeley readers. Furthermore, the Spearman correlation was obtained for the variables previously described, and the statistical significance was defined as a probability of less than 0.01.

Second, once the correlation data were obtained, we performed a factorial analysis. In this sense, factorial analysis is a statistical model that allows us to identify the common variables or *factors*that could explain the previously observed correlation. Bartlett Sphericity test (BS) and Kaiser-Meyer-Olkin (KMO) were previously performed to assess the suitability of factorial analysis (Chan & Idris, 2017).

Finally, the linear regression model was employed to achieve a more accurate expression of the relation between TE academic model and the new social paradigm of it. In this sense, we have developed a mathematical model exposing the influence of new altmetric scores in TE classical measure of impact, that is, the number of cites received by TE original articles. Thus, the linear regression equation constructed for TE behaviour contents a standard measure of impact as WoS citations and a group of alternative metrics previously identified in the factorial analysis. The free software JASP (University of Amsterdam, Amsterdam, The Netherlands) was employed to perform all the statistical analyses (Love et al., 2019).

Results

Sample

After performing the search strategy mentioned, a total of 23,179 documents were obtained from WoS for the period 2012-2018. Then a matching between the DOIs available on WoS and the Altmetrics.com data was performed, obtaining a total of 10,112 documents (43.63%) with an Altmetric score [?] 1.

Descriptive analysis

1. Presence of TE original articles in Academic and Social Platforms

We first obtained a graphical representation of how TE original articles have evolved from 2012 to 2018 in different academic and social platforms (Figure 1). The results show the percentage of documents with at least one citation or mention. Concerning WoS, the percentage of TE documents exceeds 85.00% from 2012 to 2017. The nearness of 2018 data to the present time explains the result of WoS citations in that year (40.93%) when these metadata are not already collected. The role of TE in Twitter, Mendeley readers and Altmetric Attention Score shows an upward trend from the beginning of the period studied; in this sense, the percentage of TE documents with at least one mention in the reference manager Mendeley was close to

the 50% in 2017. In contrast with it, the impact of TE research was less than 10% in terms of News, Patents and Facebook mentions for the whole period evaluated.

The behaviour of TE can be organised in three different evolutive patterns. First, the percentage of TE original articles mentioned in WoS exceeds the 80% from 2012 to 2017, suggesting the importance of traditional scores for this community; an accentuate decrease in 2018 is due to citation count was not already performed in the moment of the study. Second, a group of three variables (Number of Mendeley Readers, Altmetric Attention Score and Twitter mentions) follow a similar trend, gathering more than 25% of TE original articles mentioned in them. In this case, the Number of Mendeley Readers achieve almost 50% of mentions of TE original articles in 2017, suggesting the important role of this bibliographic database for TE researchers. Third, the presence of TE original articles is less notable in platforms such as Facebook, News and Patents since the obtained results are under 10%.

2. Top 10 TE documents ranked by WoS citations and Altmetric Attention Score.

The Top 10 TE documents ranked by their number of WoS citations and Altmetric Attention Score from 2012 to 2018 are shown in Table 1. On the one hand, the original article by Jeong-Yun Sun et al. reporting the synthesis of hydrogels from polymers ionically and covalently crosslinked networks (27) receives 1226 WoS citations being localized at the first position. In contrast, this study holds the 71st position when Altmetric Attention Score is evaluated. On the other hand, the TE original article that accumulates the higher Altmetric Attention Score is the research conducted by Joshua R. Gershlak using decellularized plants as perfusable tissue engineering scaffolds with a score of 2380. Nevertheless, this study collects 16 WoS citations.

Statistical analysis

Correlation analysis

The correlation study results are shown in Table 2. Overall, within evaluated TE corpus of literature, the number of Mendeley readers holds the best correlation results with WoS citations (P =.71). Furthermore, platforms such as Twitter (P =.17) and News (P =.14) show a suitable correlation: However, the correlation results obtained for data concerning the presence of TE in Wikipedia, Facebook, F1000 mentions and Q&A mentions were weak and, finally, a negative correlation result was observed for three bibliometric measures: Peer Review mentions (P =-.006), Reddit mentions (P =-.01) and Video mentions (P =-.03).

2. Factorial analysis

After performing correlation analysis, a value of 5,629.85 ($P<$ .001) for a chi-squared approximation of BS and 0.700 for KMO confirmed the suitability of factorial analysis. In this sense, we have identified six components that could explain the previously observed correlation data. These factors are labelled as F1, F2, F3, F4, F5 and F6 (Figure 2). Positive and negative results are indicated with green and red colour lines, respectively. The factor F1 shows the relation between WoS citations and the number of Mendeley readers. These two variables appear together, probably describing the traditional scholarly impact of TE research. The remaining factors most likely account for a different type of scientific impact in TE research.

In this regard, F3 acts as a common factor for Google and Policy mentions suggesting a relation between governmental and legal actions in TE and a widespread search source such as Google. Blogs, News and Facebook mention form a separate factor (F5). These three web-based platforms are related to a social dimension of TE diffusion and probably articulate a common factor concerning the public communication of scientific research. Finally, the number of mentions on Twitter are strongly tied to a unique factor (F4). This fact could be explained by a particular structure and behaviour of TE research within the Twitter social network.

3. Linear regression analysis

The correlation coefficient (R) and the determination coefficient (R2) are equal to 0.645 and 0.414, respectively. Thus, a positive correlation exists, and the statistical model explains more than 40% of the variation

in the number of 2018 WoS citations obtained for TE articles from 2015 Altmetrics scores. Furthermore, the result of the analysis of variance (ANOVA) test is significative for $P < .001$.

The number of Mendeley readers constitutes the best citation predictor as it holds a higher correlation coefficient with R = 0.599. The rest of the altmetrics scores have a positive correlation coefficient; however, the association is weaker.

The prediction equation for 2018 TE WoS citations counts from 2015 altmetrics scores can be expressed as follows:

Ln (1 + WoS) = -27.25 + 5.37 x Ln (1 + Blog) + 0.82 x Ln(1 + News) + 12.78 x Ln(1 + Mendeley readers) + 5.83 x Ln(1 + Patent) + 0.75 x Ln(1 + Twitter)

Discussion

Once the analysis of the online attention of the 23,179 original articles detected in WoS was performed, it is important to consider the definition of TE by Langer and Vacanti in 1993 (Langer & Vacanti, 1993). They defined TE as an interdisciplinary field that applies the principles of engineering and life sciences toward the development of biological substitutes that restore, maintain or improve tissue function. The onset and progress of TE have led to a revolution in health science practice that has also supposed a shift in contemporary medical paradigm. This revolution requires an objective quantification, becoming the employ of bibliometrics a useful tool (Grant, Cottrell, Cluzeau, & Fawcett, 2000).

In this way, we have performed an altmetric-based analysis of the core documents retrieved from WoS. First, the descriptive analysis showed the distribution of TE original articles within seven web-based platforms (WoS, Altmetric Attention Score, Twitter, Number of Mendeley readers, Facebook, Patents and News). Concerning the results reported above, the evolution of TE diffusion in Twitter stands out within the so-called social networks becoming crescent from 2012 to nowadays. The reasons for this growing probably lie in two elements: a larger diffusion of knowledge and a higher academic impact.

Regarding this larger diffusion of knowledge, the structure of Twitter, a micro-blogging platform that enables the user to communicate short messages with their virtual colleagues, has developed a singular model of scientific communication with an especial information flow (Finin, Tseng, Akshay, & Xiaodan, 2007; Kwak, Lee, Park, & Moon, 2010). A study conducted by Kwak et al. demonstrated that the retweet constitutes the nucleus of this new model of communication and, thus, retweets on TE documents can spread the information beyond the limits of their original authors, expanding them to the followers' networks (Darling, Shiffman, Cote, & Drew, 2013; Huberman, Romero, & Wu, 2009).

One of the consequences of this new model of communication is the spreading of new medical approaches for the treatment of severe untreated diseases. The information of possible new treatment, as happens in TE products, may reach through the patients to primary care physicians. For this reason, this situation is being considered in the future training of family medicine residents (Sola et al., 2019).

Respect to the consequently higher academic impact, a study conducted by Eysenbach showed that highly tweeted articles are 11 times more likely to end up being highly cited and, thus, that Twitter correlates with traditional metrics of scientific impact (Eysenbach, 2011). The upward trend of TE original articles on Twitter is probably also related to a higher academic impact of those TE mentioned documents.

Moreover, relevant information can be extracted when comparing TE original articles ranked by WoS citations and Altmetric Attention Score. Obtained results demonstrate that TE academic and social interest do not follow the same path. These results, firstly demonstrated for TE discipline, are similar to other research fields and evidence a profound discrepancy between the academic focus of interest and social assumption of scientific advances (Choo et al., 2015; Gunn, 2013) . Then, the full attention of TE research may not be well addressed through traditional metrics. According to Bornmann, citations only assess the impact of scholarly literature on those who cite, and this neglects many audiences of scholarly literature who may read, but do not cite as "pure" readers (Bornmann, 2015).

The correlation results show that citations of TE original articles in WoS are well correlated to the Number of Mendeley readers. It can be explained partly attending to the own nature of Mendeley, based on a community of bibliographic users. As a platform designed to store and share references, the use of Mendeley has been previously correlated to future citation counts in other biomedical sciences (M. a. W. Thelwall, P., 2016). In this way, this correlation also occurs in TE research area. Nevertheless, Mendeley users do not have to be publishing academics, but may also be practitioners or students (Haustein, Lariviere, Thelwall, Amyot, & Peters, 2014; Mohammadi, 2014). Therefore, the correlation could be related to a broader spectrum of TE scientific activity not only restricted to the academy.

Positive but weaker correlations were obtained for platforms such as Twitter, News and Blogs, accounting for a more accessible and open to the public kind of scientific impact. The appearance of TE original articles in Video, Reddit and Peer Review implies a fewer WoS citation count for TE original articles given that negative correlation data were observed. Probably, it could be influenced by the nature of this kind of platforms. For example, Reddit is a platform in which the virality is a crucial factor (Haralabopoulos, Anagnostopoulos, & Zeadally, 2015). According to Berger and Milkman (Berger & Milkman, 2012), those contents that evoke emotions of activation (e.g. anger, awe, anxiety) are more suitable to become viral, in contrast to deactivating emotions (e.g. softness). Therefore, papers could be mentioned to be criticized or are reporting findings that are surprising or shocking, but with low interest for the academic community.

Nevertheless, according to Thewall, correlation results could obscure relationships between variables, especially if there is one strong one (Mike Thelwall & Nevill, 2018); consequently, an exploratory factorial analysis was performed. Six factors were identified in the factorial analysis. From the analysis of these factors, two clear groups can be extracted: Academic nature (Factor 1) and social nature (Factor 4-Factor 6). Each factor accounts for an aspect of TE online attention; i.e. Factor 1 is related to traditional scholarly impact as WoS citations and Number of Mendeley readers joint together; Factor 4-Factor 6 gather different platforms that covered the social diffusion of the science. The relationship of the different platforms in F1 is not surprising since the nature of the users is similar; they are "the spot" of researchers. There are other factors which relationship is not clear. Therefore, we cannot explain the possible influence that has in the final academic impact. Factor 4-Factor 6 are the platforms of interest for the present study, they comprise some media in which the author can present their findings and try to reach the population.

Moreover, News and Facebook appear together suggesting the evidence of a newsworthiness factor while Twitter constitutes a separate one. A possible interpretation is that Twitter has a leading role in TE online attention: historical and cognitive reasons can be argued. On the one hand, the development of TE during XX century has taken place in parallel with the burst of social media and probably TE researches have substituted the idea of the academic community for the virtual department (Pogorielov, 2017; Xuemei Li, 2012). In the other hand, the structural multidisciplinary of TE (10) can be ideally appropriately displayed using social networks such as Twitter and the relations between industry, academics and clinicians could be improved without temporal or geographical restrictions (Bik & Goldstein, 2013; Kwak et al., 2010).

Lastly, Blogs are a tie in a unique factor with Peer Review mentions. In TE, blogs constitute an active space for knowledge exchange (Brown & Woolston, 2018) and to communicate science to major stakeholders (Weigold, 2001) . The association within a common factor of Peer Review and Blogs could be stated for a major reason lack of elucidation. Nevertheless, according to Weigold, the sharing of well-constructed information online contributes to informing society about real possibilities of scientific progress (Weigold, 2001); and it constitutes a pillar in TE because it offers a new therapeutically scenario for the treatment of several diseases (Li et al., 2016).

Finally, we aimed to develop a model to discover the different online influences that determine the future TE citation counts. As Thelwall declared, it is reasonable to consider Altmetric.com scores in conjunction with journal impact to get an idea of which articles are more likely to attract longer-term citations (Mike Thelwall & Nevill, 2018). Accordingly, we obtained a regression equation to derive 2018 citation counts from 2015 Almetrics.com scores for TE original articles from 2015 that Altmetric tracked. The predictive power (R^2) of the model was 10.7% when Mendeley readers were not added as an independent variable. When

Mendeley readers were considered, a value of 41.4% for R^2 was achieved, increasing the model accuracy. All regressions were statistically significant. Consequently, 2015 altmetric scores for TE original articles account for almost half of the variability in future citation counts. It follows that altmetric scores are useful if TE researchers aim to discover future citation counts. Furthermore, the different actors involved in the TE scientific diffusion should consider implementing strategies to be present in the different platforms that increase the final scientific impact.

Although the findings provided in the present paper are interesting, several limitations have to be addressed. First, only a percentage of the publications indexed in WoS is available in Altmetric.com. Therefore, the conclusions are influenced by the core obtained. Second, the factorial analysis is performed only in one year; although the behavior of the research area could be similar, it could be influenced by the published topics or other factors. Finally, the intentional tweeting by the publisher or the editor of the journal was not analyzed.

Conclusion

In conclusion, TE has supposed a revolution in daily medical practice as tissue constructs are now available to treat severe conditions previously untreated. Therefore, these new medical approaches have an impact on the population that now can be measured by the Altmetrics. These metrics differ from the classical academic metrics, but the knowledge of their influence on the final citation count could be the base of different institutional or personal decision processes. The different actors involved in the scientific diffusion of the TE can use the results obtained by the present study to raise their interest on the use of social media and other online platforms as a window to the world, not only with the intention of reaching the scientific community, but also the general society.

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CONFLICTS OF INTEREST

All authors declare that there is no financial or personal relationship with organizations that could potentially be perceived as influencing the described research.

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FIGURES

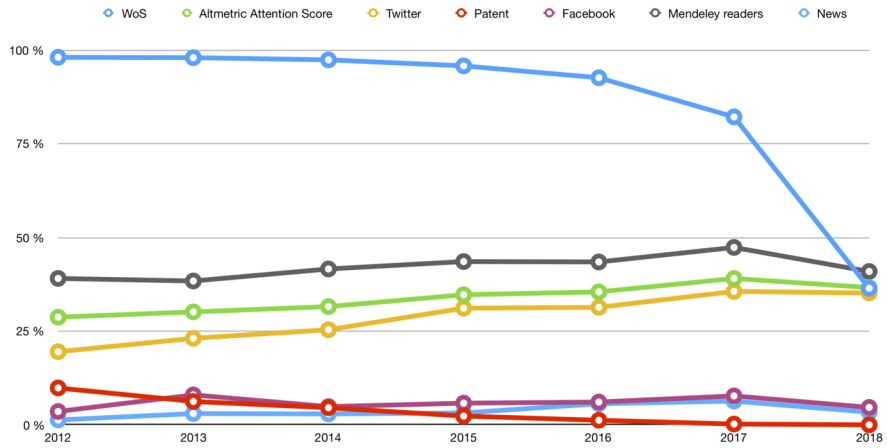

Figure 1. Percentage of documents with at least 1 citation/mention for the period 2012-2018. Only those platforms with more than a 5% in any year were represented.

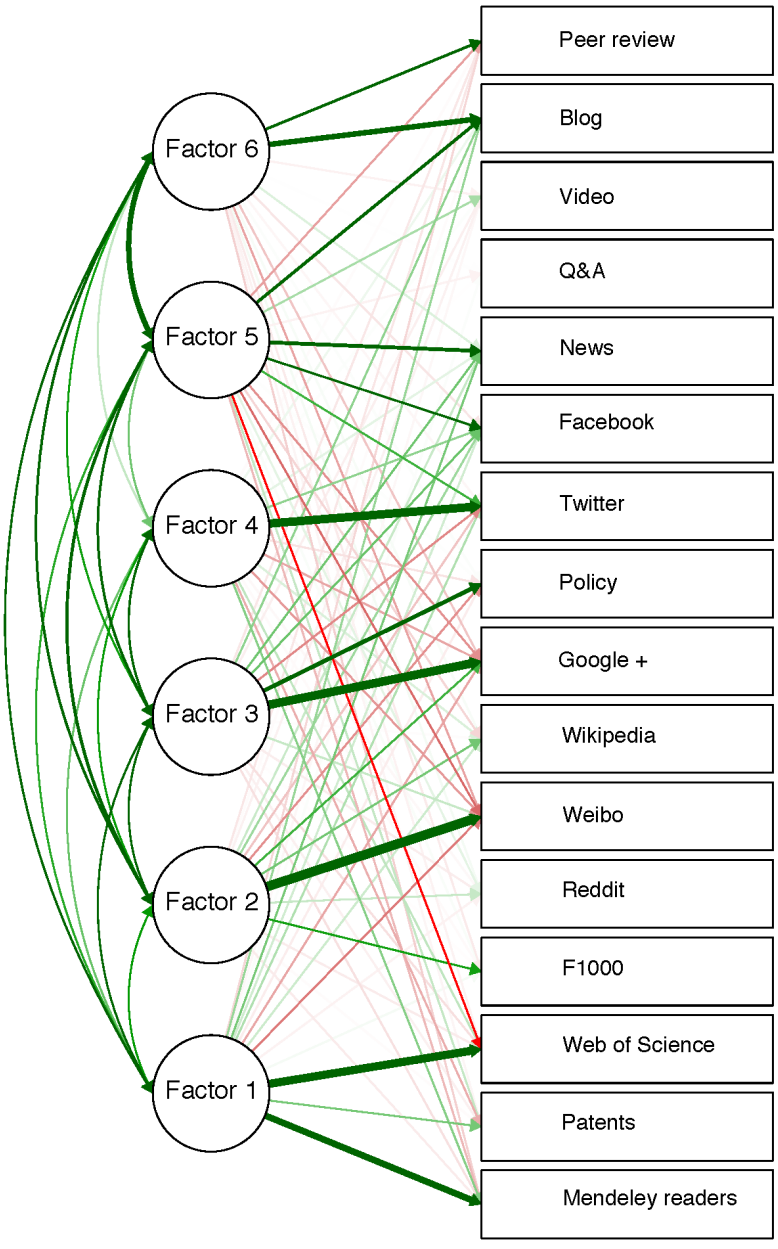

Figure 2. Factors from the factor analyses in the TE research field for the year 2015.

TABLES

WoS Rank	**Alt Rank**	**Year**	**Title**	**Source**	**WoS citations**	**Altmetric Attention Score**
WoS Citations	WoS Citations	WoS Citations	WoS Citations	WoS Citations	WoS Citations	WoS Citations
#1	#71	2012	Highly stretchable and tough hydrogels	NATURE	1226	165
#2	#2070	2013	Chitosan-based biomaterials for tissue engineering	EUROPEAN POLYMER JOURNAL	528	3
#3	#77	2014	3D Bioprinting of Vascularized, Heterogeneous Cell-Laden Tissue Constructs	ADVANCED MATERIALS	506	157
#4	#489	2012	Deconstructing the third dimension - how 3D culture microenvironments alter cellular cues	JOURNAL OF CELL SCIENCE	484	16
#5	#346	2014	Evaluation of 3D Printing and Its Potential Impact on Biotechnology and the Chemical Sciences	ANALYTICAL CHEMISTRY	451	27
#6	#1352	2013	Bone tissue engineering using 3D printing	MATERIALS TODAY	401	6

WoS Rank	Alt Rank	Year	Title	Source	WoS citations	Altmetric Attention Score
#7	#4	2016	A 3D bioprinting system to produce human-scale tissue constructs with structural integrity	NATURE BIOTECHNOLOGY	399	1472
#8	#3941	2012	Opportunities and challenges for use of tumor spheroids as models to test drug delivery and efficacy	JOURNAL OF CONTROLLED RELEASE	348	1
#9	#231	2013	Carbon-Nanotube-Embedded Hydrogel Sheets for Engineering Cardiac Constructs and Bioactuators	ACS NANO	289	53
#10	#39	2013	3D Printed Bionic Ears	NANO LETTERS	275	289
Altmetrics Attention Score	Altmetrics Attention Score	Altmetrics Attention Score	Altmetrics Attention Score	Altmetrics Attention Score	Altmetrics Attention Score	Altmetrics Attention Score
#1	#2883	2017	Crossing kingdoms: Using decellularized plants as perfusable tissue engineering scaffolds	BIOMATERIALS	2380	16

WoS Rank	Alt Rank	Year	Title	Source	WoS citations	Altmetric Attention Score
#2	#406	2017	A bioprosthetic ovary created using 3D printed microporous scaffolds restores ovarian function in sterilized mice	NATURE COMMUNICATIONS	2315	60
#3	#143	2016	Phototactic guidance of a tissue-engineered soft-robotic ray	SCIENCE	1481	100
#4	#7	2016	A 3D bioprinting system to produce human-scale tissue constructs with structural integrity	NATURE BIOTECHNOLOGY	1472	399
#5	#8853	2018	Production and transplantation of bioengineered lung into a large-animal model	SCIENCE TRANSLATIONAL MEDICINE	1067	0
#6	#309	2017	Engineered human pluripotent-stem-cell-derived intestinal tissues with a functional enteric nervous system	NATURE MEDICINE	793	69

WoS Rank	Alt Rank	Year	Title	Source	WoS citations	Altmetric Attention Score
#7	#4463	2017	In situ bone tissue engineering via ultrasound-mediated gene delivery to endogenous progenitor cells in mini-pigs	SCIENCE TRANSLATIONAL MEDICINE	740	9
#8	#6371	2017	Engineered Epidermal Progenitor Cells Can Correct Diet-Induced Obesity and Diabetes	CELL STEM CELL	628	4
#9	#3263	2016	A Quiescent, Regeneration-Responsive Tissue Engineered Mesenchymal Stem Cell Bone Marrow Niche Model via Magnetic Levitation	ACS NANO	607	14
#10	#11003	2017	Triggerable tough hydrogels for gastric resident dosage forms	NATURE COMMUNICATIONS	599	7

Table 1. Top 10 TE documents for the period 2012-2018 ranked by a) WoS citations and b) Altmetrics attention score.

	WoS	News	Blogs	Policy	Twitter	Patents	Peer review	Weibo	Facebook	Wikipedia	Googl
WoS											
News	**0,144**										
Blogs	**0,137**	**0,387**									

	WoS	News	Blogs	Policy	Twitter	Patents	Peer review	Weibo	Facebook	Wikipedia	Googl
Policy	0,049	0,065	0,064								
Twitter	**0,176**	**0,149**	**0,158**	0,009							
Patents	**0,114**	**0,093**	**0,09**	-0,009	-0,068						
Peer review	-0,006	-0,01	**0,136**	-0,001	-0,006	-0,009					
Weibo	0,04	**0,108**	**0,108**	-0,002	0,063	-0,011	-0,002				
Facebook	0,064	**0,2**	**0,213**	0,046	**0,213**	0,047	-0,014	**0,081**			
Wikipedia	0,076	0,072	0,073	-0,004	0,073	0,032	-0,004	**0,14**	0,039		
Google	0,071	**0,109**	**0,184**	**0,138**	0,073	0,013	-0,005	**0,11**	**0,184**	0,086	
Reddit	-0,012	0,008	0,028	-0,005	-0,015	-0,03	-0,005	**0,118**	0,016	-0,013	0,025
F1000	0,054	0,036	0,063	-0,003	0,05	0,013	-0,003	**0,164**	0,015	0,063	0,046
Q&A	0,003	-0,007	-0,007	-0,001	-0,004	-0,006	-0,001	-0,001	-0,01	-0,003	-0,003
Video	-0,033	0,008	0,036	-0,003	0,006	-0,02	-0,003	-0,004	0,061	-0,009	-0,011
Mendeley	**0,716**	**0,198**	**0,197**	0,021	**0,243**	**0,104**	-0,025	0,049	**0,107**	0,077	**0,098**

Table 2. Spearman correlation between pairs of variables for articles published in 2015. Bold-type indicate $p < 0.05$

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`Figures.docx` available at https://authorea.com/users/310508/articles/441373-advanced-therapies-in-medicine-and-its-diffusion-in-the-online-mass-media-a-bibliometric-analysis-of-tissue-engineering