REVIEW

Advances of Sentiment Analysis Applications in Obstetrics/Gynecology and Midwifery

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ABSTRACT

Background: Sentiment analysis, which is also referred to as 'opinion mining' or 'emotion AI', processes natural language, analyzes text and employs computational linguistics, and biometrics to identify and analyze emotions and subjective information. Sentiment analysis is mostly applied in domains such as marketing and customer service but also in clinical medicine. Clinical medicine-related sentiment analysis has advanced recently, as more and more researchers are performing studies with the help of this valuable technique, having noticed its ability to contribute in the field. **Objective:** The aim of this review was to present important facts about sentimental analysis described in deposited articles in on-line databases and the relevant articles critically appraised and a narrative synthesis conducted. **Methods:** A systematic search of four electronic databases (PubMed, APA PsycINFO, SCOPUS, ScienceDirect) was performed. This review considered only quantitative, primary studies in English language, without geographical limitations, published from 2006-2021 and relevant to the objective. Searching terms were 'Sentiment analysis' AND 'Obstetrics' OR 'pregnancy', OR 'COVID' OR 'Perinatal distress' OR 'postpartum period' OR 'fetal' OR 'breast feeding' OR 'cervical'. **Results and Discussion:** Relevant articles were critically appraised and a narrative synthesis was conducted. As a large number of studies, illustrates the use of sentiment analysis in the domain of clinical medicine, it is proved to be extremely helpful, assisting in the investigation of some highly important and even previously unexplored issues. **Conclusion:** Since pregnant women express their thoughts and feelings more openly than ever before, sentiment analysis is becoming an essential tool to monitor and understand that sentiment. Given the vast knowledge sentiment analysis has already offered, further studies employing this technique are expected in the future.
Keywords: Opinion mining, Sentiment analysis, Obstetrics, Pregnancy, Postpartum period.

1. BACKGROUND

In recent years, social media platforms like twitter are of huge importance to people's everyday lives. These platforms have become very popular discussion forums for many users around the world. Twitter allow users to post texts (known as tweets) with up to 280- characters expressing thoughts, information, comments, and observations. In many cases, the texts associated with the tweets are trended based on the real-time incidents and events. We definitely have to deal with the manifestations on these platforms, and as machine learning becomes increasingly popular and significant just like the natural language processing (NLP), we have to deal with this, and analyze and study the emotions on this platforms. Social media analysis is one of the most popular research areas nowadays. A plethora of studies apply different natural language processing (NLP) techniques. Out of these techniques, sentiment analysis is one of the most studied NLP topic. Sentiment analysis, which is also referred to as 'opinion mining' or 'emotion AI', processes natural language, analyzes text and employs computational linguistics, and biometrics to identify and analyze emotions and subjective information (1). Sentiment analysis is the process of detecting positive or negative sentiment in text. It's often used by businesses to detect sentiment in social data, gauge brand reputation, and understand customers. Since customers express their thoughts and feelings more openly in our

time, than ever before, sentiment analysis is becoming an essential tool to monitor and understand that sentiment.

Sentiment analysis is mostly applied in domains such as marketing and customer service but also in clinical medicine. Clinical medicine- related sentiment analysis has advanced recently, as more and more researchers are performing studies with the help of this valuable technique, having noticed its ability to contribute in the field.

Objective

The aim of this review was to present important facts about sentimental analysis described in deposited articles in on-line databases and the relevant articles critically appraised and a narrative synthesis conducted.

Material and Methods

A systematic search of four electronic databases (PubMed, APA PsycINFO, SCOPUS, ScienceDirect) was performed. This review considered only quantitative, primary studies in English language without geographical limitations, published during the period 2006-2021 and relevant to the objective.

Searching terms were 'Sentiment analysis' AND 'Obstetrics' OR 'pregnancy', OR 'COVID' OR 'Perinatal distress' OR 'postpartum period' OR 'fetal' OR 'breast feeding' OR 'cervical'.

Only studies that discussed sentiment analysis methods applied in obstetrics and midwifery domains were included in this study. Applications of sentiment analysis include obstetrics and midwifery related subjects from a medical as well as a psychological perspective, thus investigating a broad range of topics..

2. RESULTS AND DISCUSSION

Postpartum Period

Acknowledging the fact that postpartum period can be a time of physical and mental exhaustion for new mothers and their families, Chivers et al. (2), addressed the issue of support seeking in the transitive period from pregnancy to motherhood. In their study, investigators used an Australian web-based parenting forum in order to analyze discussions of new mothers (with infants aged 0-12 months) and determine the topics of concern. Word frequencies, sentiment analysis and post content were examined in order to trace sentiments and theoretical storylines. 260 posts were analyzed, while 13 birth clubs were employed consisting of approximately 39.163 members. Data gathered were processed by NVivo Pro 12 software (3) (QSR International). More specifically, text frequency search was able to reveal the most dominant topics of concern, while word frequency calculations traced all stemmed words (minimum three letters) and automatic sentiment analysis revealed the emotional indicators through the use of predefined scores for emotionally-charged words. Meanwhile, a slightly altered grounded theory analysis, implementing the six-face approach by Braun and Clarke (4) was chosen as most appropriate to deal with the unknown area of parenting forums (5,6). Results showed that new mothers frequently seek help through such forums and are highly influenced by them, while the most usual topics of concern deal with infant health and well-being. Unfortunately though, not many posts are observed regarding maternal physical and mental

struggling, suggesting that there is an urgent need to raise awareness on the issue and lay the groundwork for healthcare professionals to offer personalized support at a time when maternal health is sequenced below infant's needs.

Giving birth during the COVID-19 Pandemic

⊠ recent study (7), performed a slightly different study to address the issue of childbearing women's mental health during the first wave of the COVID-19 Pandemic (from March to June 2020). During a global Pandemic, the investigation of pregnancy-related mental hardships (i.e. excessive stress) becomes even more pressing, as the negative consequences on the psychological state of the mother inevitably increase, threatening her and the baby. In this study, researchers gathered pregnancy-related tweets (using GetOldTweets3) and performed a sentiment analysis (using the VADER sentiment analysis tool), as well as a thematic analysis to investigate the most common discussion topics. It should be noted that this is the first time social media are available during a global pandemic, a fact that enables researchers to collect massive amounts of data. Overall, 192 tweets were analyzed, 51 of which concerned individuals, 37 companies, 56 non-profit organizations and 48 health professionals/researchers. Unfortunately, results showed that even though individuals' tweets expressed concerns on maternal anxiety, depression symptoms, sleep deprivation and distress due to isolation, non-profit organizations and health care professionals' tweets failed to acknowledge these issues in full depth (i.e. not enough tweets on isolation and sleep difficulties) and provide adequate support to pregnant women. Meanwhile, sentiment analysis revealed that even though individuals and companies' tweets presented a global negative sentiment analysis score of -0.05, health care professionals and non-profit organizations' tweets presented a neutral score of 0.0, a discrepancy that should definitely be resolved in the near future. As far as context is concerned, it was observed that companies' and individuals' tweets differed too, as even though individuals shared their personal experiences and emotions and frequently tried to help others in similar positions, companies tried to help women in manners which could eventually draw attention to their services on the platform (22 out of 37 tweets tried to sell a service or attract people's attention on companies' website). Therefore, it is clear that in the future, efforts should be made by organizations, companies and professionals to prioritize women's mental health in pregnancy-related tweets.

Considering the unique needs of women in the perinatal period during the COVID-19 pandemic (including required guidance on matters of health, safety and risk aversion), Al-Rawi et al (8), examined social media discourse using sentiment analysis, in order to trace possible shortcomings concerning health information and support needs and explore the impacts of COVID-19 on the mothering and social identity of women. Researchers observed and analyzed online discussions which took place in a leading Australian forum for new or expecting parents. The leading forum was traced after a "new mum forum" Google search and a subsequent assessment of the first 10 results and of all websites with publicly available forums (n=7). The assessment was conducted with the help of a website analytics tool (Alexa,

Amazon.com), which established global page views, rank and Australian rank. Later on, Guerra-Reyes and McKinlay employed NVivo Pro 12 (QSR International) software to process the data and performed a three-stage analysis, consisting of thematic analysis, sentiment analysis and word frequency calculations of stemmed words. Thematic analysis was conducted using a modified grounded theory approach (informed by Braun and Clarke's[4] six phase approach). More specifically, an individual got acquainted with the data, produced initial codes and traced themes (BC) and as a second stage, a team ascertained the results while two researchers checked more than 25% of existing themes (CH and RG). Finally, NVivo Pro 12 automatic sentiment analysis and a text frequency search took place to spot emotional indicators. Results showed that the overall amount of online directives does not cover the needs of new or expecting mothers. This discrepancy between supply and demand of guidance, further increases psychological and psychosocial issues on this population, as it augments distress, feeling of insufficient social and emotional support, anticipatory grief, conflicts within the family, while it also affects family planning behavior. These results suggest that there is an immediate need for more adequate directives and strategies to reduce anxiety and concern, but also a need for support strategies or mental health interventions to deal with the loss of family/social support and medical contact that women experience due to the pandemic.

Assisted reproduction and pregnancy in COVID-19 era

However, COVID-19 does not only affect women in the perinatal period, but also women undergoing assisted reproductive technology treatments, such as IVF (in-vitro fertilization). As state directives consult hospitals and clinics to shut down in order to minimize exposure risks, obstacles increase in the already emotionally loaded process of ART treatments. Perone et al. (9), explored relevant discussions online in order to investigate the consequences of the pandemic on IVF patients. During March 2020, they collected 209 IVF patients' Instagram posts, out of which 66% were produced by patients before IVF, 16.3% during, 9.6% after and 8.1% of unknown status, and traced the following 5 recurring themes: medical and physical experience of IVF, emotional aspects, sources of social support, coping mechanisms and education on social media. It was also observed that approximately half of the posts mentioned COVID-19 (50.3%). Those posts differed significantly as opposed to others which did not mention the pandemic, among themes such as obstacles, negative emotions, social support and positive community offerings of social support (p< 0.05). Concerning sentiment analysis, results indicated that patients whose treatments did not face consequences because of the pandemic shared positive posts more frequently (happy, excited, grateful), while patients who were concerned about the negative impact COVID-19 may have on their pregnancies shared negative posts instead (sad, disappointed). Thematically, those patients seem to mention mostly concerns about fetal health, fear over the unknown nature of the pandemic and helplessness over the ceasing of their IVF treatments which contrasts with their desire to have a family. Finally, sentiment analysis also showed that there were some patients who expressed conflicting emotions (nervous but excited, anxious but scared), presumably due to the uncertainty of the pandemic. Findings of this study therefore suggest that measures should be taken in order to combat the negative psychological and social impacts of COVID-19 on the IVF community as well.

Vaccination issues

Driven by the WHO's statements on vaccine hesitancy and social media misinformation in 2019 (10), as well as the urgent need to vaccinate pregnant women to avoid neonatal morbidity and mortality, several researchers (11,12,13) investigated the main topics of discussion, attitude and relevant language for maternal vaccines on social media (Twitter, forums, blogs and comments), including data from 15 countries (Australia, Brazil, Canada, France, Germany, India, Italy, Korea, Mexico, Panama, South Africa, Spain, United Kingdom and United States) over a period of 6 months (from November 2018 to April 2019). Overall, 16.000 posts were analyzed, out of which 2.722 were annotated for emotion. Results showed that certain common topics existed across countries, namely safety of the maternal influenza and pertussis vaccines, promotion of vaccination, involvement of carrying women in vaccine research and level of trust in institutions. However, countries possessed different attitudes over vaccination with Italy (44.9%) and the USA (30.8%) expressing the most negative stance in relevant posts. Future research could shed light on the impact of the social media stance on the actual vaccination rates in specific areas.

Breastfeeding and Covid-19

Another issue that is considered to be of great importance with regards to postpartum period and COVID-19, is breastfeeding. Even though it is commonly known that breastfeeding provides a lot of short and long-term benefits to both women and children, women who were infected with COVID-19 and their families are reluctant to proceed to breastfeeding, being scared of the negative impact it may have on the child. However, it has been established that breast milk coming from women with a record of a COVID-19 infection can only have a positive impact on the baby as it carries antibodies. A Latin American study (14) addressed the specific issue, by not only examining how Mexican Media present relevant information, but also the attitude of Mexican adults regarding breastfeeding following a COVID-19 infection. For this study, researchers utilized content analysis, sentiment analysis and the SWOT analysis (strengths, weaknesses, opportunities and threats) for breastfeeding promotion. In total, 1014 publications were examined coming from different media sources (Internet, newspapers, TV, magazines) with the largest amount of data being published on the World's Breastfeeding Week in August 2020. Sentiment analysis indicated that 57.2% of the information examined was positively oriented towards breastfeeding. Meanwhile, the SWOT analysis revealed that most information was seen as strengths or opportunities for breastfeeding promotion. In spite of these results though, it was also observed that 67.3% of people who lived with children under 3 years old, had a negative stance towards breastfeeding after infection, while 19.8% stated that they did not know what was right and what was wrong, suggesting that further efforts are needed in order to inform public

opinion on the matter.

Proceeding to the issue of public breastfeeding, researchers (15) explored women's experiences in the UK by examining reviews of FeedFinder, an application which assists in spotting, reviewing and sharing places for public breastfeeding. In this study, 1.869 reviews were collected initially, out of which 1.757 were finally examined, due to the exclusion of duplicates, empty text boxes and reviews from other countries besides the UK. Sentiment analysis determined whether the reviews were positive, negative or neutral based on the different types of descriptive words used and the overall context of the review. Results showed that 80.3% of the reviews were positive, 4.1% negative and 15.7% neutral. Furthermore, it was observed that whenever a negative experience occurred, it was rarely attributed to someone forcing women to stop breastfeeding or making them feel uncomfortable (0.2%), a fact that reveals the progress accomplished in this domain compared to previous decades.

Contraception

Sentiment analysis has assisted researchers in other areas as well, including scouting public opinion on birth control. Young et al. (16), investigated the differences of positively and negatively oriented online headlines and snippets, through the use of word usage, sentiment analysis and online popularity of anti- and pro- birth control entries by Google Search engine. It was found that negative entries usually employ more emotional words (specifically when trying to communicate fear), while more positive entries seem to be approved on Facebook. In a different study (17), on short- and long- term contraceptive methods, online trends using tweets between March 2006 and December 2019, were examined. Relevant tweets were tracked, using search terms of generic or brand names, colloquial names and abbreviations. Sentiment analysis was performed and Mann-Kendall nonparametric tests were employed in order to trace the overall number of occurrence of each contraceptive method and its evaluation as positive, negative or neutral. Overall, 838.739 English language tweets were studied including at least one contraceptive method. It was observed that over the years, the number of relevant tweets escalated with the most common method being the intrauterine device (45.9%). Furthermore, it was found that short- acting methods (42%) were less popular than long-term ones (45.9%), a fact that seems to further increase as years go by. Concerning the evaluation of methods, sentiment analysis showed that whenever a single contraceptive method was discussed, the tweets turned out to be negative most of the times (95% confident sentiment, or 40.66%). On the other hand, long-term contraceptive methods were more likely to be positive than short-term methods (19.65% vs. 10.21%, p, 0.002). Given the influence of the digital world, it is evident that data extraction from social media platforms is a very valuable technique researchers could employ when it comes to understanding contraceptive decision-making and gathering information about contraception in general.

Cervical Cancer

Following the same approach (sentiment analysis), Teoh et al. (18), explored the number of tweets on cervical cancer and identified whether posts on several prevention strategies were positive or negative. Data was collected during the cervical cancer awareness month on January 2016. Results indicated that sharing personal experiences on cervical cancer was rare, even though previous studies had shown that 80% of people aged 18-24 were positive on sharing their health history online. However, healthy people were more willing to share their stories than those facing severe health conditions, a fact that presumably applies in sexually transmitted infections too (19). Regarding prevention strategies, researchers found that most posts were positive on HPV vaccination and cervical cancer screening (20,21). However, it was observed that in areas with low vaccination rates, this situation did not apply, as there were many negative posts instead (22). People against HPV vaccination have connected the vaccine to ovarian failure and autoimmune diseases, such as Guillain-Barre Syndrome, an ungrounded claim that was refuted by post-marketing surveillance (23). Despite being refuted, this claim was able to cause negative sentiment to users (24), a fact that should alert researchers to further investigate the impact on actual decision-making on cervical cancer preventions strategies.

Besides the evaluation of cervical cancer prevention strategies, sentiment analysis can also assist in creating real-time satisfaction surveys regarding clinical care. Alemi et al. (25) employed sentiment analysis, in order to separate complaints from praises with regards to pediatrician, obstetrician and gynecologist physicians in District of Columbia, Maryland and Virginia. They used comments from online sites which people use to rate clinical care, e-mails, hospital complaint registries and satisfaction surveys such as "Minute Survey". Easily available data, gave researchers the ability to establish causality of dissatisfaction and gain knowledge that would eventually lead to improvement of care and assessment of progress made.

"Vaginal mesh"

Moving on to a different issue, scientists (26) took advantage of sentiment analysis in order to explore the different attitudes, which exist online with regards to vaginal mesh. Using the Google AdWords Keyword Planner tool they performed Google searches based on 464 key words (such as "vaginal mesh") and got 46.400 results. Out of these, only 8.029 websites were considered eligible for this study, leaving out those that were not unique or those that were unrelated. Later on, researchers categorized the sample into groups, based on the type of website (i.e. legal -43.2%-, reference -22.1%- , medical -20.2%- , news/media -8.3%- and patient-generated -6.1%-), a categorization that was marked as moderately reliable (κ=0.67). Finally, the domain of the websites was mostly .com (77.4%), but others existed too (i.e. .gov, .edu, .org and .net). Results indicated that legal websites possessed a significantly increased negative stance towards vaginal mesh compared to patient-generated websites (MD, -0.09; 95% CI, -0.07 to -0.011). The same situation applied when comparing news/media websites to patient-generated ones, as the first category presented a worse mean sentiment than the latter (MD, -0.04; 95% CI, -0.02 to -0.07). Meanwhile, legal websites possessed a worse mean sentiment compared to medical websites (MD -0.12; 95% CI, 0.11 to 013), while medical and reference websites

did not seem to present any significant differences (MD, 0.01; 95% CI, -0.01 to +0.02).

Racial disparities in birth

Sentiment analysis has also assisted in tackling several previously unexplored issues, such as racial disparities in birth outcomes. Due to difficulties faced in the research process (i.e. the complicated nature of measuring racism), this problem had not been addressed on a US national level, but solely on individual level, by exploring self-reported experiences. However, the need for more extended studies is urgent, as numbers of disparities have been increasing over the years. Nguyen et al. (27,28), tried to identify the connection between state-level Twitter-derived sentiments and racial or ethnic disparities in birth outcomes. More specifically, researchers collected 26.027.740 relevant tweets from June 2015 to December 2017 and conducted sentiment analysis using a supervised machine learning model (Support Vector Machine). Training data was recovered from publicly available training datasets (i.e. Sentiment140 (n=498), Kaggle (n=7.086) and Sanders (n=5.113)), while a five-fold cross validation assessment revealed an accuracy level of 91% and an F1 score of 84% regarding the distinction of negative from positive or neutral tweets and a 89% precision level and an F1 score of 81% regarding the distinction of positive from non-positive tweets. For each year, researchers compared the sentiment analysis towards minorities and race-specific groups with birth data, concerning women with singleton pregnancies and no congenital abnormalities, whose gestational age and birth weight information were available (n=9.988.030 and n= 9.985.402 respectively). Low birth weight (smaller or equal to 2.499 g) and preterm births (gestational age smaller than 37 weeks) were observed in this population, while log binomial regression models were used to compare the incidence rates of individual maternal characteristics (sociodemographic, prenatal care, health behaviors) and state-level demographics, leading the way towards future exploration of racial disparities in birth outcomes.

3. CONCLUSION

Sentiment analysis (also known as opinion mining or emotion AI) is the use of natural language processing, text analysis, computational linguistics, and biometrics to systematically recognize, extract, quantify, and study affective states and subjective information. Sentiment analysis/opinion mining, have been acquiring a crucial role in both commercial and research applications because of their possible applicability to several different fields. This technique is used to determine whether data is positive, negative or neutral. Sentiment analysis is broadly applied to voice of the customer materials such as reviews and survey responses, online and social media, and healthcare materials for applications that range from marketing to customer service to clinical medicine.

As researches above illustrate, the use of sentiment analysis in the domain of clinical medicine has proven to be extremely helpful, assisting in the investigation of some highly important and even previously unexplored health issues. Given the vast knowledge sentiment analysis has already offered, further studies employing this technique are expected in the future.

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