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USING SENTIMENT ANALYSIS IN PATIENT SATISFACTION: A SURVEY

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ABSTRACT. The enormous amount of unstructured data is available on the internet with increasing number of users. People express their feelings or emotions in term of opinions on the web. Patient use internet sources to give review about the hospitals, doctors, medicines, treatment, etc. The data provided by the patients can help the health providers to improve the quality of their organizations. This data can also help the other patients to choose the best health facility in their regions. Most of the data available on web is in textual format. Due to its unstructured nature, it becomes difficult to extract the meaningful information from this data with traditional methods. New techniques and methods are required to analyze this massive amount of data. Sentiment analysis is the field that uses the opinions of people as an input, pre-processed them and analyze them using lexicon based and machine learning techniques. In this paper, role of sentiment analysis in patient satisfaction is discussed.

1. INTRODUCTION

In current scenario, healthcare industries are more focused on improving the experiences of patients. Patients have a lot of options to choose from varieties of services provided to them. So, Healthcare industries needs to be more active in attracting and retaining patients. USA Government sponsors the surveys such

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as HCAHPS ("Hospital Consumer Assessment of Healthcare Providers and Systems") in which the data related to patient satisfaction are being posted on the web [10]. As hospitals are continuing to improve the experiences of patients, it becomes difficult to differentiate organizations on HCAHPS score. Therefore, sentiment analysis comes into picture.

Sentiment analysis or opinion mining is a field that classifies comments or opinions into positive or negative that can be used to improve the quality. Sentiment analysis applied to patient's experiences is the systematic analysis of patient comments. Patient comments are broken into various parts and analysis is done on these components to measure how positive or negative is a patient about a particular component. Patient's Word of Mouth is the key success of the any healthcare organizations. The positive experience of patients will encourage the other patients to visit in the hospital. Patient satisfaction score can determine the quality and success of the hospital. Improvement can be done on the basis of that score to enhance the quality of the hospitals in future. Quality of care, staff behavior, environment of hospitals and basic amenities are important factors on which patient satisfaction relied. This paper surveyed the utilization of sentiment analysis techniques in patient satisfaction.

2. Related work

"Sentiment analysis of data could be original source of information" as stated by National Health Service (NHS), England[1]. The information obtained after analyzing data is valuable for patients in choosing the hospitals. Huge number of text comments on NHS website were analyzed in the study "Associations between Internet-based patient ratings and conventional surveys of patient experience in the English NHS: an observational study". The reviews provided by patients includes ratings and free text descriptions for particular aspects of care. The accuracy of sentiment analysis techniques applied against the ratings of patients was assessed. The patient experience was measured by using national survey also. Firstly, the factors affecting the patient satisfaction is discussed in this section. Then, role of sentiment analysis is being described.

[1]The Power of Information: Putting all of us in control of the health and care information we need, 2012

2.1. **Determinants of Patient Satisfaction.** Researchers worked on determining the various factors that affecting the satisfaction of the patient before using techniques of sentiment analysis for analysis purposes. It became mandatory for researchers to find the factors that affect the satisfaction of patients before analysis. The work in this field was started by measuring the aspects on which the satisfaction of patients relied. Statistical and Time to complaint methods was used for this purpose. The work done in finding the factors affecting is shown in Table 1.

Table 1: Determinants of Patient Satisfaction

Year	Author	Work Done
1997	Skaneet et al. and Marley et al.	Measured the patient satisfaction by using technical, interpersonal, social and moral aspects of care.
2001	Dawn	Found the customer feedback as valuable resource for improving the quality.
2002	Linda	Qualitative and qualitative methods for satisfying patients were studied and quantitative method was found more accurate.
2002	Yellen	Worked on instruments used to measure patient satisfaction with specific aspects of care.
2002	Nguyen et al. and Jenkinson et al.	Studied the factors that affected the patient satisfaction and found old age and health status as strong determinants.
2003	Shou Hisa	Found the health status as important factor for satisfaction of patients.
2004	Verbeck et al.	Focused on medical outcome, interpersonal factors, ethical and moral treatment of patient.
2006	Jose	Examined the relationship between various factors with satisfaction of patients.
2008	Alemi	Shown the inefficiency of statistical techniques in healthcare.
2009	Alemi and Hurd	Suggested the relationship between rate of complaints and problem with care of patients.

2010	Lagu T. et al.	Conducted review on 33 different physician rating websites and found these sites as novel way to provide feedback.
2010	Gerald B. Hickson, MD	Developed a tool named PARS in which unsolicited patient complaint data was used to identify and support interventions on high-risk clinicians.
2011	Tonio and Rama M.	Reported the contrary results for influential effect of age and gender.
2011	Oyvind	Found age, gender, education insignifant for patient satisfaction.
2012	Kupfer	Observed that higher patient satisfaction as good indicator of quality of service.
2014	Rashid Al-Abri and Amina Al-Balushi	Reviewed the factors affecting patient satisfaction.
2014	Hawthrone	Described the relationship of patient satisfaction with previous health care experiences and health outcome.
2016	Bekowitz	Related the patient satisfaction to previous experience of patients.
2017	Sandra M. Pena	Evaluated the dissatisfaction of patients with wait times using real time survey.

From Table 1, it can be observed that satisfaction of patients plays major role in improving the quality of healthcare. The inefficiency of statistical methods was also found by the researchers. Traditional methods didn't work well in handling large amount of data. Therefore, the concept of sentiment analysis came into picture for analyzing the sentiments of patients expressed on the internet. The role of sentiment analysis with their existing work will be discuss in the next section.

2.2. **Role of Sentiment Analysis.** As the feedback of customer was considered valuable resource for improving the quality of the service in any organizations. Summarizing and analyzing the opinions of the patients can play the important role in improving the quality of the service in hospitals. Also, the statistical methods were found inefficient in measuring the satisfaction of the patients, researchers started to use the sentiment analysis methods in measuring the patient satisfaction.

Sentiment analysis on healthcare data have been done on the comment, entity or aspect level. Various approaches, i.e. machine learning, corpus-based and lexicon-based approaches has been applied by the researchers. Various methods of machine learning were applied by [1–5, 7–9, 11, 13, 18, 19, 21, 23–25, 28]. Sentiment lexicon for healthcare was generated by using general lexicon SentiWordNet and Subjectivity Lexicon by [6,12,22]. Hybrid techniques, i.e. by combining lexicon and machine learning has been applied by [14,15,20,27] analysis purpose. A report has been presented by [10] that utilized sentiment analysis and time-to-next complaint methods on information containing text. A framework for patient complaints was designed by [16]. Vijay Shanker Gupta [17] conducted online survey and hospitals were selected on the basis of satisfaction rate of the patients by using big data analytics tools. Detection of sarcasm and development of hospital recommender system based on comments and views of patients were left as future work. Sunil Gohil [26] reviewed the tools available for sentiment analysis of twitter healthcare data and determined the best method for healthcare setting by analyzing usage of methods. Researchers reported the need of sentiment analysis tool trained specifically for healthcare tweets.

The study of various methods used by researchers is shown in Table 2.

Table 2: Comparison of existing work done

Year	Author	Approach	Method Used	Level of Analysis
2005	Niu et al.	Machine Learning	SVM	Sentence
2006	Niu et al.	Machine Learning	SVM	Sentence
2009	Xia et al.	Machine Learning	Multi-class Classification	Comment
2011	Sokolova M. & Bobicev V.	Machine Learning	Naive bayes, SVM and decision Trees	Comment
2011	Farrokh Alemi	Machine Learning	Decision Trees, SVM, Naive Bayes Multinomial	Comment
2012	Goeuriot L.et al.	Lexicon Based	SentiWordNet and Corpus based approaches	-
2013	Greaves F.	Machine Learning	Decision Trees, SVM, Naive Bayes Multinomial	Comment

2013	Biyani et al	Machine Learning	Semi supervised approach	Comment
2014	Zhao	Machine Learning	Classification Algorithms	Comment
2015	Despo Georgiou et al.	Machine learning and sentiment analysis tools	-	-
2016	Rodrigues et al.	Lexicon Based	SentiStrength, Semantria	Comment
2016	Korkontzelos et al.	Machine Learning	Sentiment 140, Conditional Random Field, Subjectivity Lexicon	Comment and Entity
2016	Asghar et al.	Lexicon Based	SentiWordNet and Corpus based approaches	Comment
2016	Del Arco FMP	Corpus, Lexicon and Machine Learning	Sentiment Orientation and Machine Learning	-
2016	VijayShanker Gupta	Big data Analytics tools	Hadoop and R	Comment Level
2016	Padmavathy P. and Anny Lemma A.	Machine Learning	LDA and K-Means Clustering,	Aspect Level
2017	Gopalakrishnan and Ramaswamy	Machine Learning	SVM, Neural Networks	Comment
2017	ElMessiry et al.	Hybrid	LIWC Lexicon with Naive Bayes Classifier	-
2017	ElMessiry et al.	Machine Learning	SVM, Random Forests, Max Entropy, Boosting	Patient Complaints
2017	Sales-Zarate et al.	Lexicon based	SentiWordNet	Aspect Level
2017	Alayba et al.	Machine Learning	Naive Bayes, SVM, Regression and Neural Networks	Comment
2018	Xia et al.	Machine Learning	SVM, Gradient Boost Decision Tree (GBDT), Random Forests and LSTM	Comment

2018	Shweta Yadav et al.	Machine Learning	Neural Networks	-
2019	F.J. Ramirez-Tinoco et al.	Hybrid Methods	-	Comment and Entity
2019	Kashfia S.	Machine Learning	Naïve Bayes and k-means Clustering	Comment

Sentiment analysis has great utilization in healthcare domain. From Table 2, it can be observed that the techniques of sentiment analysis can be applied on various fields in health care domain in successful manner. It can be seen that more work has been done on comment and entity level. Most of researchers used machine learning tecniques instead of lexicon approaches which shows the importance of thie technique. Hybrid techniques of sentiment analysis can be applied on dataset of patients in healthcare domain to get better results as compared to lexicon and machine learning methods alone. Next section describes the research directions in this field.

3. Discussions and challenges

The goal of healthcare sentiment analysis is to identify the health facilities and identify what people like or dislike about them. Patients complaints and suggestions can motivate the organizations to improve their facilities for the future. The various challenges in this field that can be derived from the work are as follows:

(i) To find the authentic set of patient opinions for sentiment analysis.
(ii) Constructions of domain specific lexicon for health care.
(iii) Applicability of hybrid methods on aspect level to search the health-related solutions closely matching to the need of patients.
(iv) Detection of irony and sarcastic sentences in patient comments.
(v) Analysis of opinions in language other than English, i.e. multilingual sentiment analysis.

These are the challenges faced by researchers while working on sentiment analysis in health care. Next section concludes the paper.

4. Conclusion

As patient satisfaction is the major factor for improving the quality of hospitals. The factors affecting the satisfaction of patients has been discussed in this paper. Applicability of sentiment analysis techniques in patient's satisfaction is also described. The utilization of these techniques in the health care domain can be shown from the related work. Researchers faced many challenges while applying these methods in patient opinions that has been discussed in previous sections.

References

[1] Y. Niu, X. Zhu, J. Li, G. Hirst: *Analysis of polarity information in medical text*, AMIA Annual Symposium Proceedings Archive, **2005** (2005), 570–574.

[2] Y. Niu, X. Zhu, G. Hirst: *Using outcome polarity in sentence extraction for medical question-answering*, AMIA Annual Symposium Proceedings Arcive, **2006** (2006), 599–603.

[3] L. Xia, A. L. Gentile, J. Munro, J. Iria: *Improving patient opinion mining through multi-step classification*, International conference on text, speech and dialogue, Springer, Berlin, Heidelberg, (2009), 70–76.

[4] M. Sokolova, V. Bobicev: *Sentiments and Opinions in Health-related Web messages*, In Proceedings of the International Conference Recent Advances in Natural Language Processing 2011, (2011), 132–139.

[5] F. Alemi, M. Torii, L. Clementz, D. C. Aron: *Feasibility of real-time satisfaction surveys through automated analysis of patients' unstructured comments and sentiments*, Quality Management in Healthcare, **21**(1) (2012), 9–19.

[6] L. Goeuriot, J. C. Na, W. Y. M. Kyaing, C. Khoo, Y. K. Chang, Y. L. Theng, J. J. Kim: *Sentiment lexicons for health-related opinion mining*, In Proceedings of the 2nd ACM SIGHIT International Health Informatics Symposium, (2012), 219–226.

[7] F. Greaves, D. R. Cano, C. Millett, A. Darzi, L. Donaldson: *Use of sentiment analysis for capturing patient experience from free-text comments posted online*, Journal of medical Internet research, **15**(11) (2013), e239.

[8] P. Biyani, C. Caragea, P. Mitra, C. Zhou, J. Yen, G. E. Greer, K. Portier: *Co-training over domain-independent and domain-dependent features for sentiment analysis of an online cancer support community*, 2013 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining, (2013), 413–417.

[9] K. Zhao, J. Yen, G. Greer, B. Qiu, P. Mitra, K. Portier: *Finding influential users of online health communities: a new metric based on sentiment influence*, Journal of the American Medical Informatics Association, **21**(e2) (2014), e212–e218.

[10] A. M. HOPPER, M. URIYO: *Using sentiment analysis to review patient satisfaction data located on the internet*, Journal of health organization and management, **29**(2) (2015), 221–233.

[11] D. GEORGIOU, A. MACFARLANE, T. R. ROSE: *Extracting sentiment from healthcare survey data: An evaluation of sentiment analysis tools*, In 2015 Science and Information Conference (SAI), (2015), 352–361.

[12] R. G. RODRIGUES, R. M. DAS DORES, C. G. C. JUNIOR, T. C. ROSA: *SentiHealth-Cancer: a sentiment analysis tool to help detecting mood of patients in online social networks*, International journal of medical informatics, **85**(1) (2016), 80–95.

[13] I. KORKONTZELOS, A. NIKFARJAM, M. SHARDLOW, A. SARKER, S. ANANIADOU, G. H. GONZALEZ: *Analysis of the effect of sentiment analysis on extracting adverse drug reactions from tweets and forum posts*, Journal of biomedical informatics, **62** (2016), 148–158.

[14] M. Z. ASGHAR, S. AHMAD, M. QASIM, S. R. ZAHRA, F. M. KUNDI: *SentiHealth: creating health-related sentiment lexicon using hybrid approach*, SpringerPlus, **5**(1) (2016), 1–23.

[15] F. M. P. DEL ARCO, M. T. M. VALDIVIA, S. M. J. ZAFRA, M. D. M. GONZALEZ, E. M. CAMARA: *COPOS: corpus of patient opinions in spanish*, Application of sentiment analysis techniques, **57** (2016), 83–90.

[16] A. GILLESPIE, T. W. READER: *The Healthcare Complaints Analysis Tool: development and reliability testing of a method for service monitoring and organisational learning*, BMJ quality and safety, **25**(12) (2016), 937–946.

[17] V. S. GUPTA, S. KOHLI: *Twitter sentiment analysis in healthcare using Hadoop and R.*, In 2016 3rd International Conference on Computing for Sustainable Global Development (INDIACom), IEEE, (2016), 3766–3772.

[18] P. PADMAVATHY, A. A. LEEMA: *Sentiment Mining from Online Patient Experience using Latent Dirichlet Allocation Method*, Indian J Sci Technol, **9**(19) (2016), 1–7.

[19] V. GOPALAKRISHNAN, C. RAMASWAMY: *Patient opinion mining to analyze drugs satisfaction using supervised learning*, Journal of applied research and technology, **15**(4) (2017), 311–319.

[20] A. ELMESSIRY, Z. ZHANG, W. O. COOPER, T. F. CATRON, J. KARRASS, M. P. SINGH: *Leveraging sentiment analysis for classifying patient complaints*, In Proceedings of the 8th ACM International Conference on Bioinformatics, Computational Biology, and Health Informatics, (2017), 44–51.

[21] A. ELMESSIRY, W. O. COOPER, T. F. CATRON, J. KARRASS, Z. ZHANG, M.P. SINGH: *Triaging Patient Complaints: Monte Carlo Cross-Validation of Six Machine Learning Classifiers*, JMIR medical informatics, **5**(3) (2017), e19.

[22] M. D. P. S. ZARATE, J. M. MOREIRA, K. L. ORTIZ, H. L. AVEIGA, M. A. R. GARCIA, R. V. GARCIA: *Sentiment analysis on tweets about diabetes: an aspect-level approach*, Computational and mathematical methods in medicine, **2017** (2017), 1–9.

[23] A. M. ALAYBA, V. PALADE, M. ENGLAND, R. IQBAL: *Arabic language sentiment analysis on health services*, In 2017 1st International Workshop on Arabic Script Analysis and Recognition (ASAR), IEEE, (2017), 114–118.

[24] C. XIA, D. ZHAO, J. WANG, J. LIU, J. MA: *ICSH 2018: LSTM based sentiment analysis for patient experience narratives in E-survey tools*, An International Conference on Smart Health (2018), 231-239.

[25] S. YADAV, A. EKBAL, S. SAHA, P. BHATTACHARYYA: *Medical sentiment analysis using social media: towards building a patient assisted system.*, Proceedings of the Eleventh International Conference on Language Resources and Evaluation (LREC 2018), 2018.

[26] S. GOHIL, S. VUIK, A. DARZI: *Sentiment analysis of health care tweets: review of the methods used*, JMIR public health and surveillance, **4**(2) (2018), e43.

[27] F. J. R. TINOCO, G. A. HERNANDEZ, J. L. SANCHEZ-CERVANTES, M. DEL P. S. ZARATE, R. V. GARCIA: *Use of sentiment analysis techniques in healthcare domain*, Current Trends in Semantic Web Technologies: Theory and Practice, Springer, Cham. (2019), 189–212.

[28] K. SAILUNAZ, R. ALHAJJ: *Emotion and sentiment analysis from Twitter text*, Journal of Computational Science, **36** (2019), 101003.

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