Exploiting Literature-Based Discovery to Study Effects of Bullying

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ABSTRACT

Bullying represents an aggressive behavioral problem. It can create severe mental illness in children, adolescents, and adults. Researchers are interested in studying bullying to understand its long-term negative consequences and design better-targeted intervention programs. Broadly researchers in psychology and education have conducted studies on bullying without using advanced analytical features offered by the computer science domain. However, researchers could benefit from power of advanced analytics for an in-depth understanding of bullying. In this paper, we present graph-based advanced analytics by employing a literature-based discovery (LBD) approach to study the direct and indirect consequences of bullying from published literature. In addition, we describe a graph-based study on the evolution of research on bullying consequences in the last two decades. Our graph-based study reveals a summary view of associations of bullying with other diseases and disorders from published literature. Moreover, we employ literature reference information to quantify the strength of the graph-derived relationships. Furthermore, we propose an interactive Graphical User Interface (GUI) design to study bullying. We demonstrate that LBD is a valuable approach to perform advanced analytics on bullying that helps us to understand the severity of its consequences.

CCS CONCEPTS

• **Software and its engineering → Software creation and management**.

KEYWORDS

bullying, literature-based discovery, graph analytics

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1 INTRODUCTION

Bullying is an abuse delivered in the form of threatening, demeaning, and belittling a person by a physically stronger individual or one with a higher social status than the victim [18]. Children, adolescents, and even adults are victims of bullying [21]. However, young people are at the highest risk [1]. Bullying can create serious mental distress [10]. Moreover, combined with additional risk factors, being involved in bullying, increases the possibility of engaging in suicide-related behaviors [10]. Furthermore, not only the victims but the atmosphere is affected by bullying. Research studies show that individuals who experienced bullying behavior problems at school age have a tendency to participate in criminal behavior as adults, including racial attacks, damage to public property, sexual attacks and even killing [8].

Bullying is an increasingly interesting topic for researchers, because of growing evidence demonstrating long-term negative outcomes for both bullies and victims. The researchers aim to identify the causes of bullying in order to find effective intervention programs targeting the risk and protective factors related to the involvement in bullying. However, it is difficult to study bullying behavior because it is frequently covered up or fabricated (eheck [22] for detail) [36]. Historically, experts in psychology and education have conducted studies on bullying but other fields such as computer science, big data, and virtual communities can provide a significant contribution by offering new perspectives and innovative approaches to studying bullying and developing efficient bullying interventions [15].

Despite the fact that the bully-victim problem had existed previously, the first systematic studies were only conducted in the early 1970s [26, 34]. In the early stage, studies were performed in Scandinavia, US, Japan, Australia, and UK in the, 1970s, 1980s and 1990s [27]. As stated in US national data, approximately 15% of youngsters experienced cyberbullying and 20% were bullied at school in 2013. Moreover,

8% of students reported being bullied daily [15]. The rate of bullying among children is fairly consistent; nevertheless, researchers have found bullying among adults as well [29]. This phenomenon is particularly prominent in the work environment. According to the "Workplace Bullying Survey 2014," 72% of Americans reported being aware of bullying in the workplace, 21% witnessed it, and 27% suffered abusive conduct at work [37].

In this paper, we present a summarized view of bullying's direct and indirect consequences. The literature-based discovery (LBD) method is employed to identify bullying's short-term and long-term impacts from the published literature. Moreover, we present a systematic discussion on how research on bullying consequences evolves over time. We utilize Semantic MEDLINE, a web application that manages the outcomes of PubMed searches by visualizing SemRep predications collected from MEDLINE citations [24]. We demonstrate that LBD is a useful approach for domain researchers, to discover logical relationships between bullying and its harmful impacts.

We review previous work on LBD in Section 2. In Section 3, we present our research methodology. In Section 4, we provide a detail discussion of our research results. In Section 5, we discuss propose user interface design and Section 6 concludes the paper.

2 BACKGROUND

Literature-based discovery (LBD) uses published literature to identify new interesting relationships between existing knowledge regarding a given phenomenon [33]. One of the early work on LBD was conducted by Don R. Swanson. The author employed LBD technique to study fish oil [33]. Swanson apply LBD to find the connection between Migraine and Magnesium as well [12]. Hristovski, Friedman, Rindflesch, and Peterlin proposed to use semantic predication to increase the strength of the LBD [17]. Miller et al. employed LBD to do hypothesis testing. In their study, authors found that testosterone and sleep have a connection via cortisol [24]. Gordon and Lindsay utilized LBD to find the link between Raynaud's disease and dietary fish oil [13].

3 METHODOLOGY

There are two main components of our research. First, we study the direct and indirect effects of bullying. Second, we examine the evolution of the patterns depicted in bullying consequences in published literature. We employ semantic MEDLINE tool to conduct our research. We present description of the semantic MEDLINE and our research components below. Throughout the paper, Unified Medical Language System (UMLS) concept names are italicized.

Semantic MEDLINE

Semantic MEDLINE is a web-based application that provides biomedical document retrieval, summarization, and visualization services [30]. This application uses MEDLINE citations generated from PubMed searches [19, 30]. Semantic MEDLINE employs a natural language processing tool called SemRep to find semantic relationships (or predications) from the titles and abstracts of PubMed citations [38]. SemRep examines each sentence in PubMed titles and abstracts to extract meaningful relationships [30]. For example, SemRep obtains the relation *psychological distress* COEXISTS_WITH *bullying* from the following citation "The Impact of School Social Support and Bullying Victimization on Psychological Distress among California Adolescents (PMID:27708555). However, all the SemRep relations are not meaningful. For example, Semantic MEDLINE shows that citation [14] creates *bullying* and *vitelliform dystrophy* relationship. However, there exists no such relationship in citation [14]. Thus, it is necessary for us to read the citations carefully to find out the soundness and strength of the relationships.

SemRep relationships are presented in a triple form as it contains three parts: subject, predicate, and object. In the above example, the subject is *psychological distress*, the predicate is COEXISTS_WITH, and the object is *bullying*. Subjects and objects represent concepts taken from the UMLS's Metathesaurus, and predicates are collected from the Semantic Network (SN) [24]. Semantic MEDLINE provides visualization of the relationships as a graph (or network) by considering the subject and object as nodes, and the predicate as an edge. The graph edge provides citation information and the sentence from which the relationship is extracted. We present an example visualization in Fig. 1 where *psychological distress* and *bullying* maintain a COEXISTS_WITH relationship (left side of the figure). The citation sentence from which the relationship is extracted is shown in red on the right side of the figure. Semantic MEDLINE provides numerous node types and relations (edges) based on a citation search. We refer readers to the SemMed documentation for additional discussion on this topic [4].

Find Effects of Bullying

We utilize semantic MEDLINE to discover direct and indirect effects of bullying. We use the free UMLS license to access the semantic MEDLINE.

To find the direct effects of bullying, we query semantic MEDLINE with the keyword "bullying" and pursue the following steps:

Step 1: We use the date range (01/01/1900 - 06/30/2017) and the search options (Most recent: 500 citations) to return the relevant citations.

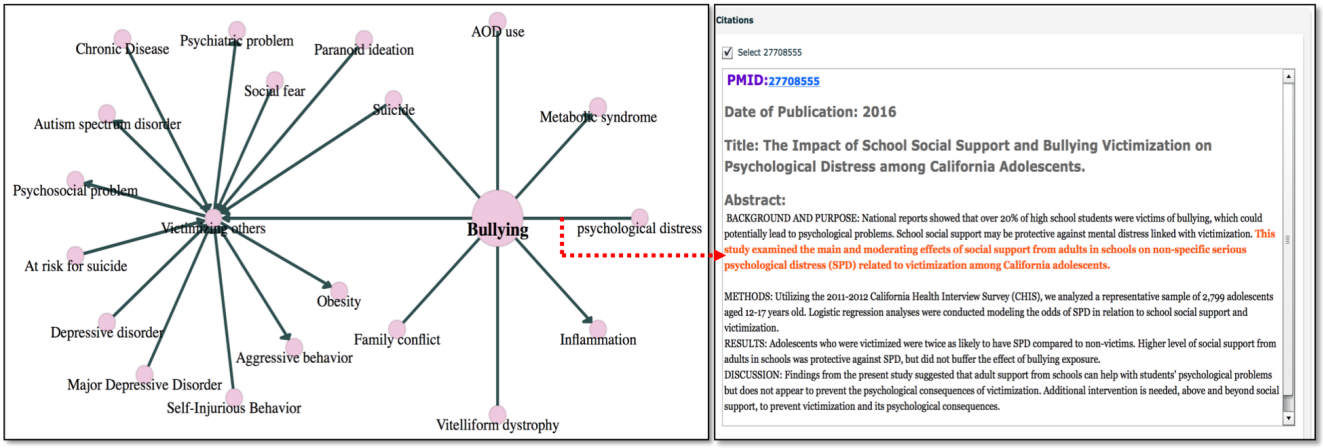


Figure 1: Semantic MEDLINE web application.

Step 2: We summarize the citation by using Summary Type: Treatment and Disease and UMLS concept that occur in the relations the maximum number of times. We also check the "More Relations" checkbox to utilize all the relations. Summarization provides us relations in a subject, predicate, and object format. It also presents the citation sentence (from where the relation is extracted) and PMID.

Step 3: We visualize the summarized results in a graph where nodes (UMLS concepts) are the subjects and objects, while edges are predicates (from the Semantic Network). We use the COEXISTS_WITH relation in our study.

Step 4: We obtain the corresponding citations for each relation from the graph edge. Finally, we read the citation to identify meaningful relations.

To find indirect effects of bullying, we first search semantic MEDLINE with all the UMLS concepts that co-occur with "bullying" (example: Fig. 2-Level 2) and follow the four steps mentioned earlier. Next, with the results obtained in the first phase, we search semantic MEDLINE again (see example: Fig. 2-Level 3) and repeat the above four steps.

Exploring the Evolution of Research on Bullying

We aim to understand the evolution of bullying research over time. We consider COEXISTS_WITH relationship. We observe from semantic MEDLINE that first UMLS concept COEXISTS_WITH *bullying* in the year 1995. Next, from 1995, we expand our search date by five-year periods leading to *bullying* COEXISTS_WITH graph for the years 1995, 2000, 2005, 2010, 2015, and 2017 (Semantic MEDLINE provides data up to the year of 2017). We generate six graphs with numerous relations. To quantify the importance of a relationship, we search Google Scholar [2] with relationship's citation title(s) to collect "Cited By" (another citation refers to a relationship citation) information.

Note: "Cited By" information is one of importance measurement metric. However, it may not be appropriate for some cases.

4 DISCUSSION

Effects of Bullying

In the following section, we present our discussion on direct and indirect effects of bullying based on literature-based discovery. We query semantic MEDLINE with keyword "bullying" and use the date range from 01/01/1900 to 06/30/2017, which provides the recent citations on bullying. We obtain many relationships from semantic MEDLINE. Furthermore, we discuss few relations as examples.

Direct Effect. We observe that *bullying* concept appears directly with the following concepts: 1) *suicide*, 2) *alcohol and other drugs (AOD) use*, 3) *metabolic syndrome*, 4) *psychological distress*, 5) *inflammation*, 6) *family conflict*, and 7) *victimizing others*. The relationship between *bullying* and *suicide* comes from the citation [32] where authors study "why bullying leads to suicidal thoughts and behaviors." The study performed on 340 depressed adolescents and their ages were 13-19 years. In this study, it was observed that controlling for internalizing symptoms, age, overt and reputational bullying maintains an association with periodic past month suicide attempts. Moreover, the authors noted that for male victims, victimization leads to risky behavior engagement before suicide attempts whereas for female victims, bullying was directly related to suicide attempts [32]. *Bullying* and *AOD use* relation comes from citation [16]. In their study [16], the authors found that in spite of the severity of internalizing problems, substance use maintains independent connections

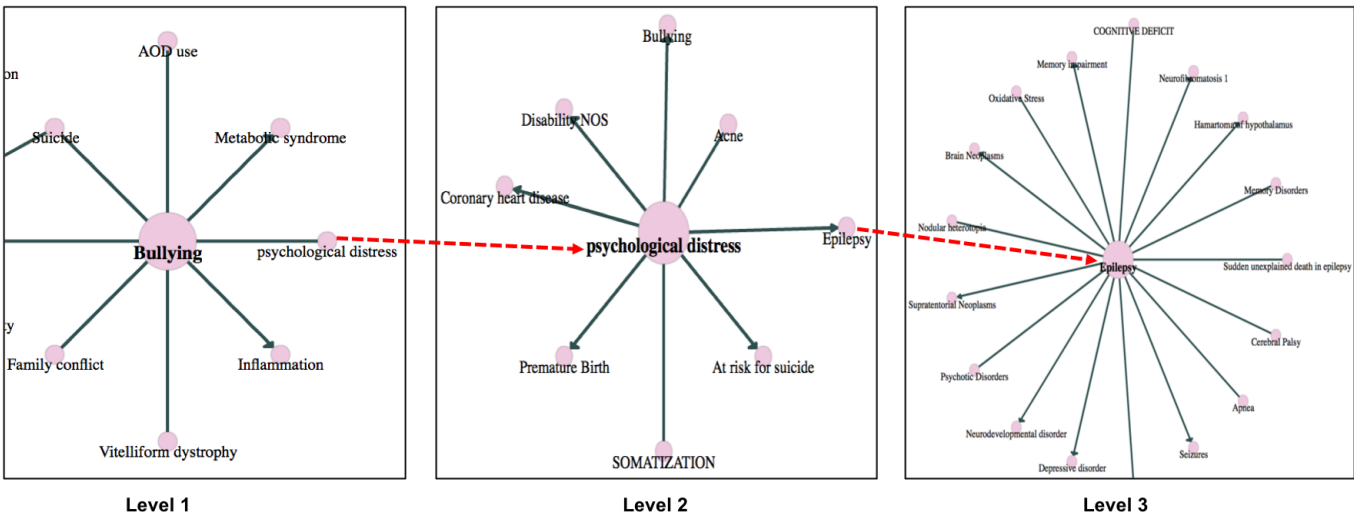


Figure 2: In this figure, we present our three-level approach example for bullying's indirect effects identification. In Level 1, we present all the concepts co-occur (first neighbor) with bullying. One of them is psychological distress. In Level 2, we show psychological distress's first neighbors and Epilepsy is one of them. In Level 3, we display Epilepsy's first neighbors.

with both negative peer norms and bullying. The citation [23] provides bullying's co-occurrence with *metabolic syndrome* and *inflammation*. The citation [23] describes that childhood bullying has no relationship with *metabolic syndrome* and *inflammation*. Hence, it means that not all the relationships present in semantic MEDLINE are positively correlated. The relationship between *bullying* is directly connected to *psychological distress*, and bullied young people are susceptible to experience serious psychological distress (SPD) twice more than non-bullied young people [39]. *Bullying* is also connected to *family conflict* via *psychological distress* [35]. Many citations (e.g., [28], [9]) in semantic MEDLINE suggest that *bullying* concept maintains ISA (sameAS) relationship with *victimizing others*. Hence, in our study, we consider them synonymous.

Indirect Effect. In the earlier section (Direct Effect), we mention that *bullying* has a relation with *psychological distress* [39]. We search semantic MEDLINE with *psychological distress* and find that it has a relationship with *at risk for suicide*, which is shown in citation [6]. In citation [6], the presented results showed that Suicidal behavior is positively associated to psychological distress. Next, we search semantic MEDLINE with *at risk for suicide*. We find that *at risk for suicide* maintains relationship with *diabetes mellitus* suggested by citation [11]. In the citation [11], the authors observe that diabetes mellitus is strongly connected with an increase in suicidal behaviors and ideation.

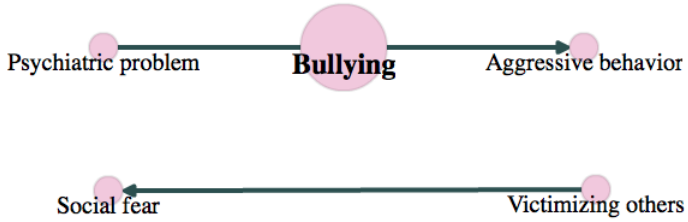
While *bullying* has relation with *psychological distress* [39], *psychological distress* has a relationship with *epilepsy* [20]. In the citation [20], the authors discussed that psychological distress has significant impact on epilepsy. We search semantic MEDLINE with *epilepsy* and find that *cognitive deficit* has a relationship with *epilepsy* [31].

We discussed the connection between the *bullying* and *suicide* before. Now, we search semantic MEDLINE with concept *suicide* and find that *suicide* has relationship with *eating disorders* [7]. In the citation [7], via self-image-based prediction, the authors showed that suicide has association with eating disorders. Subsequently, we search semantic MEDLINE with *eating disorders* and find that it has a relationship with *obesity* [25]. In the citation [25], the authors demonstrate a connection between eating disorders and obesity by distinguishing "Fear of Obesity" and "Self-Esteem Based on Shape and Weight." However, their study has some limitations.

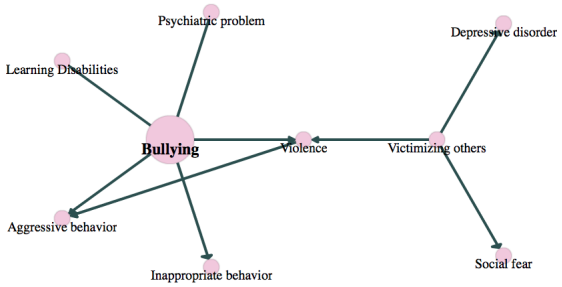
Evolution of Bullying Research Literature

Our study shows that bullying research is continuously growing as indicated in Fig. 3, which shows relationship of bullying with other concepts that have been established within various time frames. According to Fig. 3(a), *aggressive behavior* is the first disorder that COEXISTS_WITH with bullying in the year 1995. The 1995 graph contains only two nodes and one edge. After five years, in the year 2000, in addition to *aggressive behavior*, bullying is co-occurring with *psychiatric problem*, *victimizing other* and *social fear* (Fig. 3(b)). The 2000 citation graph contains five nodes and three edges. That is, the research work in the time-frame 1995-2000 has established these additional relationships.

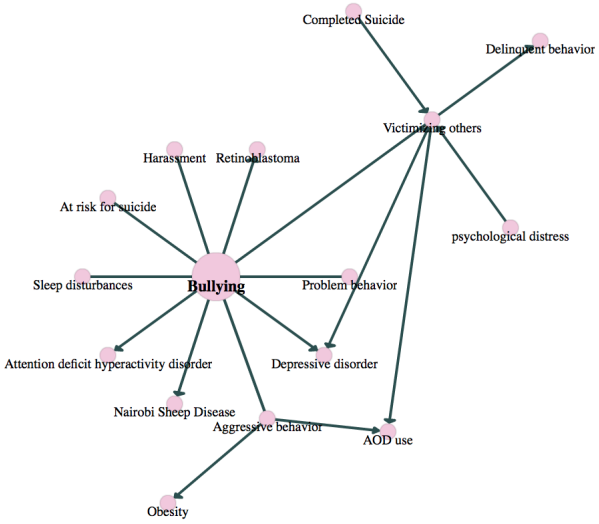
(a) Bullying research graph from 01/01/1900 to 06/30/1995.



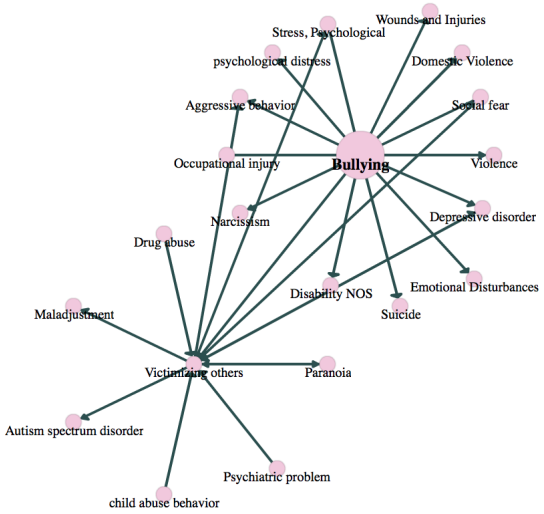
(b) Bullying research graph from 01/01/1900 to 06/30/2000.



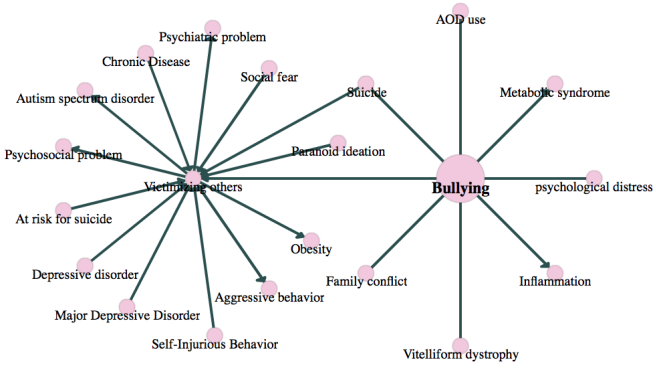
(c) Bullying research graph from 01/01/1900 to 06/30/2005.



(d) Bullying research graph from 01/01/1900 to 06/30/2010.



(e) Bullying research graph from 01/01/1900 to 06/30/2015.



(f) Bullying research graph from 01/01/1900 to 06/30/2017.

Figure 3: In this figure we show, evolution of bullying research literature graph. Here we present all the COEXISTS_WITH relationships.

Considering bullying and *victimizing other* synonymous, as shown in Fig. 3(c), in the year 2005, the number of edges (relationships) doubled from 2000. Moreover, Fig. 3(c) illustrates some of the serious consequences of bullying like *violence*, *learning disability*, and *depressive disorder*. The research effort on bullying increases significantly in the year 2010 as the corresponding graph contains 15 nodes and 17 edges (Fig. 3(d)). Dangerous relations like *completed suicide*, *at risk for suicide*, and *retinoblastoma* are occurred in this graph. Also, Fig 3(d) presents some interesting secondary relationship of bullying. For example, bullying occurs with *aggressive behavior* and *aggressive behavior* occurs with *obesity* and *alcohol and other drugs (AOD) use*. In the graph for 2005, *depressive disorder* maintains an indirect relationship with *bullying* (*depressive disorder–victimizing others–violence–bullying*). However, in the 2010 bullying graph *depressive disorder* maintains a direct relationship with *bullying*. In the year 2015, the graph expands by a large margin, which contains 21 nodes and 24 edges. This graph shows a direct relation between *bullying* and *suicide*. We consider it an important relationship because numerous research studies are performed on this relationship. A number of interesting concepts appear in the graph (Fig. 3(e)); in the following we provide some examples: *autism spectrum disorder*, *paranoia*, *drug abuse*, *narcissism*, etc. Besides, like earlier, in the 2010 bullying graph *psychological distress* maintains an indirect relationship with *bullying* (*psychological distress–victimizing other–bullying*). However, *psychological distress* maintains a direct relationship with *bullying* in 2015 graph. In 2017 graph (Fig. 3(f)), we have 21 nodes and 21 edges. In this case, the growth is smaller as the gap between the year 2015 and 2017 is only two years. However, in these two recent years, interesting concepts such as *family conflict*, *self-injurious behavior*, *chronic disease*, *paranoid ideation*, and *inflammation* appear in the graph.

From Semantic MEDLINE, we collect citation titles of the relations available (shown in Fig. 3). We search Google Scholar with these titles to find their "cited-by" count. The cited by information is collected on April 3, 2018. The citation with title "Bullying: its roots in pre-school aggression." represents the single edge in the graph shown in Fig. 3(a). We did not find this citation in Google Scholar. Fig. 3(b)'s top citation title is "Bullying behaviour and psychosocial health among school students in New South Wales, Australia: cross sectional survey", that established the relation between *bullying* and *psychiatric problem*, has been cited 581 times. For 2005 graph (Fig. 3(c)), we identify relationship between *victimizing others* and *depressive disorder* very important because the corresponding citation (title: Does bullying cause emotional problems? A prospective study of young teenagers) is cited 1,057 times. We consider the connection between *bullying* and *harassment* are important for (Fig. 3(d)) because corresponding citation "Does online harassment constitute bullying? An exploration of online harassment by known peers and online-only contacts" is cited 533 times. Similarly, for Fig. 3(e) the connection between *victimizing others* and *psychiatric problem* is important because corresponding citation "Cross-national time trends in bullying victimization in 33 countries among children aged 11, 13 and 15 from 2002 to 2010" is cited 73 times. Finally, for the year 2017 (Fig. 3(f)), we acknowledge *Victimizing others* and *Psychosocial problem* is a vital relationship (citation title: "Consequences of bullying victimization in childhood and adolescence: A systematic review and meta-analysis", cited by 20 times). We observe that many mental diseases and disorders are co-occurring with bullying over the time leading to strong ties between bullying and mental disorders.

5 USER INTERFACE

A Graphical User interface (GUI) can be developed on top of semantic MEDLINE and Google Scholar citation data for interactive data analysis. Semantic MEDLINE data is available in [5]. "Scholarly" software [3] can be employed to get Google Scholar data. Next, it is possible to create a Resource Description Framework (RDF) database based on semantic MEDLINE and Google Scholar datasets and a GUI on top of the RDF database. RDF database allows incorporation of ontologies as well.

We propose a web-based system called "Bullying Analytics" which support semantic search, indirect effect finding, and aggregated statistics. We present system designs in Figs. 4, 5, 6.

Semantic Search

Semantic Search permits users to formulate user define queries with a GUI that uses ontology-driven search. Fig. 4 shows how Semantic Search retrieves bullying literature that contains "Female" and "Depression" related terms and the total cited-by count is more than or equal 10. By using "Add Statement" button, researchers can incrementally formulate a complex query which helps to find precise information. Query results (literature title, published year, and cited-by) are presented in the results section.

Pathfinder

This service allows users to find indirect effects of bullying and interactive graph-based visualization from published literature. A user can define hope size as well. Fig. 5 presents how bullying indirect effects can be retrieved where hope size is 3 and relation types are COEXISTS_WITH and CAUSES. Users can click an edge of the graph to get detail publication information. Moreover, users can check whether a edges in the path is correct or not and provide "Correct" or "Incorrect" information through "Feedback" section. Path graph updates

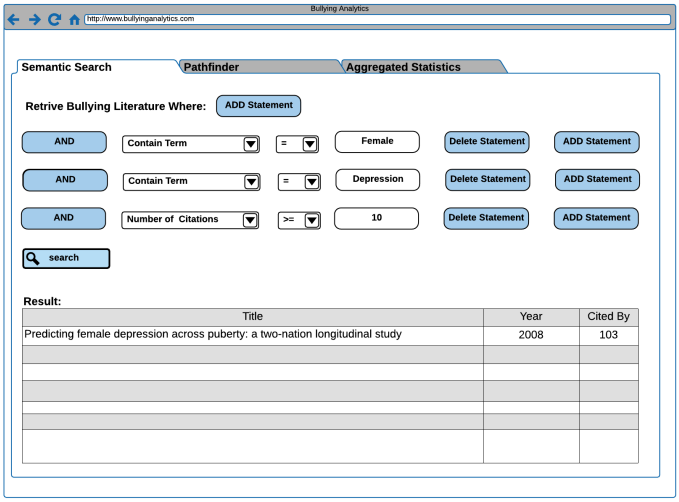


Figure 4: Semantic Search.

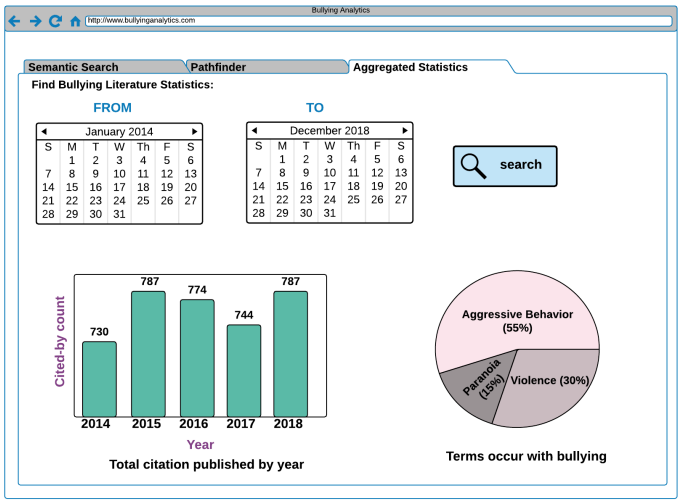


Figure 6: Aggregated Statistics.

based on users feedback. Pathfinder service allows users to find a long chain of indirect effect interactively.

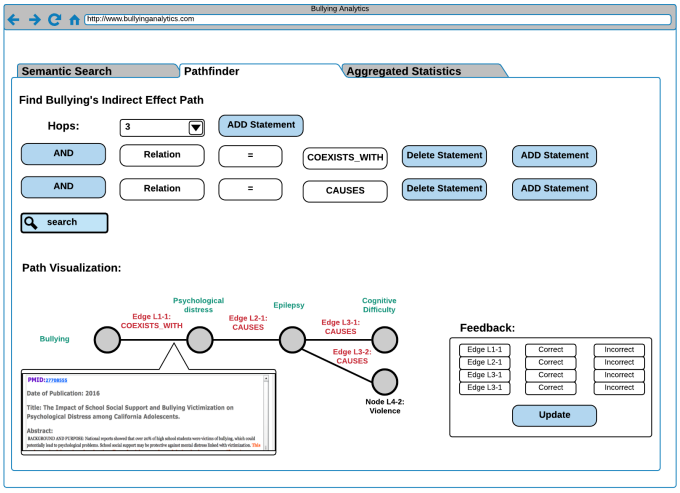


Figure 5: Pathfinder.

Aggregated Statistics

Fig. 6 shows aggregation service that "Bullying Analytics" provides. Users can select a start and end date. Based on users selection the GUI presents the total number of bullying-related citations published by year as a bar chart. Moreover, GUI presents top disease, or disorder related terms occurred in bullying literature as a pie chart (a partical example is provided in Fig. 6).

6 CONCLUSION AND FUTURE WORK

In this paper, we describe an LBD approach to study bullying. We show that the LBD approach is capable of performing advanced analytics on bullying. In this paper, we present a small number of direct and indirect consequences of bullying. Our future work include development of a software tool to find the long chain of meaningful indirect consequences automatically. It is challenging to design a software that can understand literature semantics. We also plan to use graph algorithms (e.g., PageRank) for advanced analytics.

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