Abstract

The recruitment of human subjects for clinical trial research is an imperative step in the discovery of new cures for diseases. However, the current major recruitment methodologies are inherently inefficient. Intelligent workflow management has great potential for improving the clinical trial recruitment process and overcome some of the limitations. In this paper, we present an intelligent workflow system for clinical trials, called MindFlow as an alternative to the traditional workflow model for clinical trials. With an increasing capacity of analysis of clinical trial processes, this model can enhance the efficiency and quality of recruitment of patients with psychiatric disorders for clinical research. The MindFlow system is based on data mining approaches, ontology and visualization technologies. The MindFlow system offers a simulation of clinical trials workflow based on published outcomes and analysis/prediction with data mining and visualization of the processes involved. We believe that the system particularly valuable in enhancing recruitment for clinical trial studies for development of new drugs.

1. Introduction

The recruitment of human subjects for clinical trials research is a critically important step in the discovery of new cures for diseases. About 1,450 new clinical research protocols each year are designed for clinical trials testing new treatments. Recruitment is particularly challenging for trials involving vulnerable, psychiatrically-disordered groups. Considerable resources are expended in efforts to recruit adequate numbers of patient volunteers who meet the inclusion/exclusion criteria for clinical trials. However, the current major recruitment methodologies are inherently inefficient.

Thus, effective and safe clinical trial workflow is a key for speed translation of promising laboratory discoveries translated into better medical treatments.

A wide variety of strategies and tactics are currently used to increase recruitment. In recognition of the significance of this problem, several strategies have been employed to attract, select and retain participants in clinical trials. These are based on assuming that the following types of intervention at an early stage are likely to lead to increased recruitment of volunteers and their participation in clinical trials:

- Increased awareness of clinical trials research:
  - Media advertising, informational sessions or brochures on individual/community benefits
- Increased trust in a clinical trial:
  - Letters of introduction signed by prominent persons or the name of a university included in information disseminated about the clinical trial
- Continued communication with subjects:
  - Follow up phone calls to acknowledge interest and indicate potential for participation.
- Less paperwork/simple protocol:
  - Simplified consent forms
- Financial compensation:
  - Fee-based recruitment, raffles for volunteers
- Assurance that all patient subjects will benefit from the trial:
  - Modes of treatments instead of placebos
- Proactive recruitment strategies:
  - Active case finding methods, e.g., the placement of recruitment coordinators in health centers.

The above strategies have met with varied degrees of success. The recruitment of human subjects for clinical trials via the traditional methods of phone-based and face-to-face interviews is inefficient. This is one of the factors resulting in the high recruitment cost of clinical trials. There is considerable scope for improving on the current paradigm for recruiting. Ideally, one should be able to eliminate unsuitable patients or volunteers before initiating expensive screening and evaluation. However, this is often discovered only after

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1 NIH Factsheets http://report.nih.gov/NIHfactsheets/
considerable time and effort have been invested by both volunteer subject and clinical trial personnel. We envision intelligent workflow management as having great potential for improving the clinical trial recruitment process by overcoming several of its limitations. Scientific workflow focuses on sharing know-how to incorporate the people and processes dealing with the heterogeneity and the mess\(^2\). The analytical pipelines of the workflow are essential to integrate datasets and processes for sharing methods of published outcomes. This paper presents an intelligent workflow management system called MindFlow (the subsystem of the clinical trial system MindTrial \cite{1}) that will enhance the efficiency and quality of recruitment of patients with psychiatric disorders for clinical research (Fig. 1). The MindFlow system focuses on optimizing recruitment for clinical trial studies which can lead to “go - no go” decisions, which will commit or spare increasingly crucial financial resources for development of new drugs. The MindFlow system interacts with potential subjects, but also provides research practitioners the ability to manage overall activities of clinical trials – scheduling, communications, monitoring, planning, and evaluation. As a first step towards validating the system, the initial version of the system has been implemented with a case study of clinical trials for Generalized Anxiety Disorder (GAD).

The remainder of the paper is organized as follows: Section 2 introduces related work on workflow management in clinical trials. Section 3 presents the proposed workflow management system for clinical trials. Section 4 shows the experimental results. Section 5 concludes this paper.

2. Related Work

There has been some progress in the development of clinical trial systems. The Volunteer for Vanderbilt Research Program \cite{2} is a good illustration of the benefits of using even a basic website for volunteer initiated recruitment. Minimal information is captured by the website and searches by recruiters are limited to age, race, gender, disease interest, BMI, height, and weight. In contrast to the broad scope of the Vanderbilt online resource, the Interactive Autism Network\(^3\) (IAN) is focused on enhancing recruitment and providing a knowledge network focused on a single disorder. TrialX \cite{3} is one of the more advanced online trial search systems based on semantic matching of trials with personal health records. Embi et al. \cite{4} present a clinical trial alert system that notifies the physician when it finds an eligible patient for an ongoing clinical trial. There have been efforts for developing automated clinical trial workflow management and clinical practice protocols and guidelines. Fig. 2 shows a comparative analysis of existing Event-driven workflow systems \cite{5-10} that can be used for clinical trials. Only a few of these models take account of social networking, data mining and semantic techniques for workflow management. Taverna \cite{7} is a semantic model that is completely dynamic and communicates through command line and remote execution internet. However, it is domain independent and focuses more on workflow execution. In addition, the work by Besana et al. \cite{8} is closed to our work with respect to eligibility clustering and ontology approach for searching patients. However, they do not support some important features such as communication, social networking and data mining.

In contrast to these systems, the MindFlow system is an intelligent workflow approach to enhance the quality and efficiency of recruitment for clinical trials. It will allow users to assess the likelihood that a specific clinical trial site will be able to successfully recruit and retain volunteers for a given study. Enhanced knowledge about demographic, diagnostic


\(^3\) Interactive Autism Network http://www.ianproject.org/
and state-based characteristics of potential volunteers will also reduce the risk of confounding diagnoses spuriously introducing signs/symptoms into study results that might be interpreted as adverse events (AEs) and also improve the statistical power. The online nature and personalized interface of the system will facilitate recruitment and retention of populations that may be under-represented, or particularly difficult to recruit/retain for clinical trials, such as racial minorities, women, and pediatric groups.

This is particularly important in view of evidence of variable therapeutic responses and AEs in these groups relative to the broader patient population. We believe that potential clients will also find this system to be of use in determining the feasibility design and execution of trials, based on the availability of populations likely to meet inclusion/exclusion criteria and based on predictive factors likely to influence the probability of successful recruitment and retention. We also feel that the public profile of clinical research will be elevated by a proactive and well-structured process with an emphasis on patient education and the informed consent process, when contrasted with the current paradigm that is heavily dependent upon mass media advertising typically performed ad hoc as the need to recruit for a new study arises. We think this is particularly important in a highly politicized and legalistic era of increasingly negative societal views of the pharmaceutical industry.

3. MindFlow: Workflow in Clinical Trials

3.1. Workflow Model

The MindFlow model is an event-driven intelligent model (Fig. 3) in selection of appropriate strategies for effective recruitment management, at the level of a trial or for individual subjects. The activities conducted in the clinical trial process can
be represented as an activity and each activity is composed of several events.

Utilizing the MindFlow model, each subject interacting with the system would have a personalized and optimized experience. For instance, some, while wishing to participate in clinical trials, may not have the patience to complete detailed questionnaires. It might be a better strategy to obtain minimal information by dynamically switching to an abbreviated questionnaire that still gathers useful input. In turn, questionnaire modules that are either left incomplete or marked in an inconsistent fashion might point to a need to redesign the questionnaire. This level of dynamic optimization is achievable by the meticulous compilation of statistics, not just on subject data, but also interaction patterns of potential subjects with the system. The accruing data can be subsequently mined by algorithms to improve the overall effectiveness of the clinical trial recruitment process. The MindFlow system will have the capacity to learn from “dropout” and positive “survivor” cases. For the effective planning of the recruitment process, rule based machine learning can be used to study the positive and negative patterns to reveal strategies to increase the number of survivors and minimize the number of dropouts.

The corresponding milestones are Efficiency of collection of accurate information relevant to the recruitment process: Demonstration that the system has a comprehensive and intelligent internet-aided approach to the recruitment process. Improvement of subject knowledge: Demonstration of improved knowledge by patient subjects of critical elements of clinical trials that are important for demonstrating the capacity for giving informed consent. Enhancement of satisfaction: Demonstration of enhanced satisfaction by potential subjects, professional recruiting staff and clinical trial professionals representing the new drug development industry, when compared with traditional recruitment methods. Discernment of recruitment for Generalized Anxiety Disorder: Demonstration that the prototype is able to delineate and differentiate the critical operational parameters for enhancing recruitment of subjects with a specific psychiatric disorder (i.e., GAD). The ability of the prototype to accurately and efficiently filter diagnostically relevant information will be particularly important, where the number and diversity of patients and diagnostic categories will grow significantly. Effectiveness of iterative improvement model: Demonstration that changes in operational parameters of the prototype, as a result of feedback from data regarding the efficiency and adequacy of recruitment in mock study recruitment, lead to additional improvements in the efficiency and adequacy of recruitment in subsequent mock recruitment trials.

3.2. Characteristics of Clinical Trials

One of the major obstacles to completing clinical studies is the shortage of participants who take part in the studies. For the analysis and prediction of the effectiveness for the recruitment process, we consider the multiple dimensions as follows.

![Fig. 3. MindFlow Model](image)
3.2.1. Study Specific: This dimension includes population of specific diseases, side effects, duration of clinical trials, phase of study, and the amount of compensation. The statistics extracted from the National Institute of Mental Health (NIMH) shows some interesting patterns between anxiety disorders and adult age groups in USA. For Generalized Anxiety Disorder (GAD), Panic Disorder and Post-Traumatic Stress Disorder (PTSD), the dominant age group is 45–59, while Obsessive-Compulsive Disorder (OCD), Social Phobia and Specific Phobia is 30 – 44. Also, Specific Phobia and Social Phobia are common disorders (afflicting at least 3% of US adult population) while Agoraphobia and Obsessive-Compulsive Disorder (OCD) are rare (less than 1% of US adult population). It would be a challenge to find appropriate subjects for some clinical trials that require subjects to have uncommon disease characteristics. These indicate that different requirement strategies should be applied for subject recruitments depending upon the medical conditions of the clinical trials.

A side effect or adverse event may occur during the treatment of clinical trials due to reaction to medication or application of the study device within a previously specified period of time after the treatment has been completed. Depending upon specific conditions for a particular study, we may anticipate quite different types of side effects. For example, the mental disorder treatment, the most common side effects or adverse events are nervousness, nausea, drowsiness, and weakness. If the severities of side effects are very high then the recruitment of subjects would be very hard.

3.2.2. Subject Specific: This dimension includes subject specific: gender, ethnicity, age, social/cultural/family/educational/economical background, and prior experiences with clinical trials. The NIMH study shows that women are 60% more likely than men to suffer with Anxiety Disorder. Non-Hispanic blacks are 20% less likely, and Hispanics are 30% less likely than whites. Also, there are special issues with women and family statuses that affect their abilities to participate such as responsibilities due to child birth, child care, complication with overnight stays, far distances from the research site, long periods of time away from house work, and lack of access to transportation.

3.2.3. Organization/Community Specific: This dimension includes location of studies, cultural and ethnic community, attitudes of people involved in clinical trials (staffs, recruiters, lab technicians, and doctors), and effectiveness of clinical trials process/management. The characteristics of the community of the research site are also important factors for success in clinical trials: a rural or an urban community, the various cultural or ethnic groups, and the structure and characteristics of local health care systems and settings.

3.3. Data Mining for Clinical Trial Workflow

3.3.1. Positive and Negative Pattern We define Positive/Negative patterns as Association Patterns from Survivor/Dropout cases of clinical studies, respectively. We incorporate algorithms to discover prediction/decision rules for effective recruitment. We developed a recruitment model using data mining approaches (decision tree and association rule mining) to build positive and negative patterns from previous recruitment data and use them to classify new data. A negative pattern example can be that procedures are too invasive and/or fear and mistrust of the medical system. A positive pattern is related to race and proximity to trial enrollment centers were significantly related to age of trial participants. Thus, we need to study the effect on recruitment of important variables such as demographic factors (e.g., age, gender, ethnicity, education, marital status, employment) and status of depressive disorders and anxiety, chronic health conditions, medications, and health-related quality of life. We analyzed previously published rules (risk factors, incentives) in devising strategies to maximize the utility efficacy and increase recruitment. Once we have sufficient historical data, we expect to validate our approach of using prediction rules to select appropriate strategies during the recruitment process. Ultimately, more thorough models shall be iteratively defined by tuning parameters.

This level of dynamic optimization is achievable by the meticulous compilation of statistics, not just on subject data, but also interaction patterns of potential subjects with the system. The accruing data can subsequently be mined by algorithms to improve the overall effectiveness of the clinical trial recruitment process. For example, the system will have the capacity to learn from negative “dropout” and positive “stick-with-it” cases.

3.3.2. Utility Efficacy Estimation In the MindFlow system, we model the process considering the effectiveness and safety of clinical trials. The process can be estimated based on the patterns discovered from similar previously studied outcomes. The typical recruitment process for a hypothetical study and displays an analysis of the loss of potential
recruits at each step of a clinical research. The eight stages are shown as follows:

- Stage 1: Phone call (interested in study)
- Stage 2: Phone Screen completed by staff
- Stage 3: Screens meeting criteria for assessment by psychiatrists
- Stage 4: Phone Screen subjects by psychiatrists (to detect possible correlations underlying recruitment appropriate and called)
- Stage 5: Phone screens by psychiatrists where contact was made and disposition determined
- Stage 6: On Site Screens requested
- Stage 7: On Site Screens completed
- Stage 8: On Site Screens meeting Inclusion and Exclusion Criterion

Three parameters are particularly important to monitor as functions of each step in the recruitment process: Number of volunteers, Time required for the step, and Expense associated with each step. Ideally, of course, in order to determine the ability of our prototype to optimize each of these parameters, we would compare the recruitment and retention results of a CT employing our prototype versus the traditional model.

In MindFlow, we define the Evaluation Function (EV) considering five different dimensions:

\[ EV(E, O, S, C, T) = \sum(W_{i1}F_{i1}(E_{i}) + W_{i2}F_{i2}(O_{i}) + W_{i3}F_{i3}(S_{i}) + W_{i4}F_{i4}(C_{i}) + W_{i5}F_{i5}(T_{i})) \]

where E is an effectiveness measurement like p-value, O an enrollment, S side effect, C cost, T time and \( W_{i1} \) to \( W_{i5} \) is a predefined weight for these dimensions. The root causes for Drop out are exclusion and obstacles while the root causes for Survivor are inclusion and incentive. The evaluation function will maximize the number of qualified participants and the effectiveness of treatment with minimum side effects. We now define the Utility Function (\( \delta \)) based on EV considering the workflow process (previous, current, future) as follows:

\[ \delta(EV) = e_{3}a + e_{5}b + e_{3}r \]

where \( e_{3}a \) is the accumulated utility cost for previous stages, \( e_{5}b \) is the utility cost for the current stage, and \( e_{3}r \) is the expected utility cost for the remaining stages.

In MindFlow, we developed an assessment system and “curve-fitting” intelligent recruitment system illustrated in Fig. 1. The application of these measures in actual clinical research can provide data that clients (e.g. pharmaceutical firms, critical trial sites) can then compare with their own data regarding critical trial expense. MindFlow builds agreements with clients to be able to monitor and apply such information to further refine the workflow model.

The prototype provides a software component for automatically modifying elements of the dataset question modules and assessing the recruitment outcome. The prototype will then retain approaches that move the recruitment process towards the ideal; the most efficient design in a “curve-fitting” manner, as depicted schematically. Human oversight and management of the system will, of course, occur at every step. However, we believe that a software-driven, empirical approach will produce optimal results and perhaps, lead to surprising insights about the best recruitment methods.

Our utility efficacy model (Fig. 4) considers the perspectives of both the recruiter and the recruited to determine the cost-effectiveness of recruitment process and planning. The objective of the model is to maximize the number of qualified participants while minimizing the overall utility efficacy (time and effort). The utility model is incremental because the efficacy degree of the three phases of past, current, and future efficacy will be continuously evaluated. The purpose of this analysis is to make better decisions on selecting cost-effective strategies.

In this example, we use four recruitment attributes and two strategies: \( A1 = \) Age (old), \( A5 = \) Gender (woman), \( A6 = \) Ethnicity (white), \( A3 = \) Distance to Center (close), \( S2 = \) Face-to-face interaction and \( S4 = \) Incremental Process.

The initial estimates are derived from published data, government documents, and expert opinions collected by a survey. With time, several of the estimates are derived from our own data collection. More importantly, the stages close to the final stage will be more critical compared to the initial stages.

### 3.3. Adaptation of Eligibility Criteria

Study of unintended/unexpected consequences of inclusion/exclusion criteria can guide the adjustment of the criteria that are a better fit to the current and target patients of clinical research. For instance, if the majority of subjects fail eligibility based on a single criterion, it might be worthwhile to study the criterion and see if it can be altered without affecting the scientific integrity of the study. The intelligent planning model will facilitate the systematic design of the research questions by suggesting adjustments to eligibility criteria of inclusion and exclusion depending upon extensive analysis of patients, protocol, and research sites. It is also important to identify differences between those who are eligible and enrolled and those who do not enroll either through attrition during screening or ineligibility.

A general set of introductory questions, common to all volunteers, contains a subset of disease-specific
probing questions that launch appropriate sets of detailed questions. These are based on standard criteria like those in the “Diagnostic and Statistical Manual of Mental Disorders (DSM-IV).” The generation of the questionnaire is interactive to ensure that i) questions are not redundant and ii) sufficient details are elicited based on the specific medical background of the volunteer. General questions cover basic demographic information (e.g., name, address), medical corroboration information (e.g., names of psychiatrists, physicians and facilities visited, past tests performed), trigger questions to suggest detailed questionnaires to be used (e.g., known diagnoses, history of suicidal behavior), and questions related to consent for being contacted and/or access to clinical records.

Fig. 4. Data Mining Model for Effective Recruitment

Appropriate disease-specific questions are triggered based on the responses to the general questionnaire. These are framed as checklists and multiple choice questions with the aim of capturing a rich amount of detail without resorting to free text input. Furthermore, this allows the detection of inconsistencies in volunteer responses to reduce the probability of having the system corrupted by spurious data. Volunteer responses can be mapped to Clinical Trial databases to validate the eligibility for participating in a clinical study. In addition, the online administration of well-validated psychometric testing can be performed. These would be routinely and frequently administered to samples of the given group and therefore provide a statistically-reliable measure of psychometric characteristics of the diagnostic group populating the database at any given time point.

3.4. Effective Communication

Effective communication is based on intelligent processing in the selection of appropriate strategies for recruitment, at either the level of a trial or for individual subjects. Ideally, each subject interacting with the system should have a personalized and optimized experience. For instance, some might prefer a graphical interface and others a textual/chart interface; some might prefer Spanish to English. Some, while wishing to participate in clinical trials, may not have the patience to complete detailed questionnaires. It might be a better strategy to obtain minimal information by dynamically switching to an abbreviated questionnaire that still gathers useful input. In turn, questionnaire modules that are either left incomplete or marked in an inconsistent fashion might point to a need to redesign the questionnaire.

There are several important questions to be addressed. What is the best way of communication with subjects? It is depending upon subjects, level for communication, communication type, etc. It is essential to better understand the unique characteristics of different types of subjects. Given these factors, we would like to determine patterns of communication based on user profiles and kinds of activities. It would be useful to identify distinct user profiles that represent identifiable subjects of interest to direct candidates with unique media characteristics and attitudes for direct effective communications. Even if this is not a comprehensive view of all subjects, they do provide a glimpse into how to build a profile and one-to-one communications with each individual candidate of clinical trials. In MindFlow, we model different message types to be sent to the participants for a particular event such as screening. The types of messages exchanged for scheduling events include confirmation, reminder, not available, rescheduling, cancellation.

3.5. Eligibility Match Making

The Eligibility Matchmaker supports customized searches for potential recruiters based on user profiling and study profiling. Specifically, we provide two kinds of matchmaking interfaces for selecting potential volunteers. One is based on a detailed fine-grained checklist view where fields identical to those in the questionnaire can be selected as inclusion (desired) or exclusion (NOT desired) criteria. In addition to exact matches for the query, near matches are displayed, ranked by semantic and information theoretic considerations. The second kind of query interface is based on summarized queries that are expanded by an intelligent middle layer and computed on a subset of volunteer responses. For example, if a recruiter types in “Generalized Anxiety Disorder,” this will be mapped to the appropriate set of questions (e.g., self-reported diagnosis, medical record diagnosis, suggestive answers to relevant questions) and the matching
3.6. System Implementation

The MindFlow system is implemented as Web Services (using ASP.Net and C#) with Microsoft SQL on the .NET Platform. Specifically, .NET Chart controls were used for the visualization of data, XML parser was built to extract data from the clinical trials.gov site. Several important Web Services (for Weka4 data mining tool and Semantic clustering and matchmaking approach [1]) were developed for profiling the clinical trial studies and subjects in clinical trials. The MindFlow prototype system (Fig. 5) provides a search feature based on conditions of clinical study with five components: Workflow Diagram, Enrollment, Drug Effectiveness, Cost Analysis, and Adverse Event Analysis. The workflow diagram is a high level workflow model of the whole clinical trial process. Different phases are divided by the vertical lines and the activities are shown as a rectangle. The Enrollment chart shows the number of subjects involved in the study starting from the recruitment process to the end of the study treatment. The real and estimated numbers of participants in the study are shown in different phases.

We also can see the number of dropouts in the study in different phases. In the Drug Efficiency chart, for each study conducted in the trial, the drug efficiency is viewed as the mean p value for the specific group of patients. The estimated result is also shown. The cost analysis figure reveals a rough estimation of cost per head in each phase of the clinical trial. However, the total cost depends on the event costs and the number of subjects in each phase. The Adverse Event chart shows the number of occurrences of the adverse event (major and minor) that took place during the course of the trial. It captures each side effect and the corresponding number of subjects affected by them in all phases.

These features would be useful to review the comprehensive recruitment status, including the number of contacts made, the associated demographic information, and the number of qualified/disqualified participants for a given study. It can provide up-to-date information such as automated and personalized follow-up with patients and recruiters, as well as online interactive and personalized recruitment and study evaluation, and an outcomes report (Fig. 6).

The MindFlow integrates data from heterogeneous data sources and carry out real time data analysis, provide data indicating the efficiency of recruitment with information on cost savings, and

4 http://www.cs.waikato.ac.nz/ml/weka/
determine the most appropriate sites for a given study based on the location of potential patients. The system can be used to educate users about the clinical trial process, provide means to the patients willing to participate in clinical trials, and provide means for the recruiters to monitor the health information of enrollees.

4. Experimental Results

We analyzed clinical trial study results to illustrate the MindFlow approach on clinical trials involving subjects with Generalized Anxiety Disorder (GAD). A total of 12 clinical trial study results matching the query term “Generalized Anxiety Disorder” were downloaded from ClinicalTrials.gov on May, 2011. Only 10 studies including participants, user profile, dropout reasons, and adverse events are used for this analysis.

Fig. 7 shows the GAD study completion rates for these 10 studies. The worst completion rate was 45% (for Study S1) while the best was 91% (for Study S10). Adverse (serious and other) events have been analyzed for these 10 studies. Interestingly, Studies S1 and S2, (relatively low completion rates, 45% and 62%, respectively), showed high rates with both serious and other adverse events (Fig. 8).

Fig. 9 shows the most common dropout reasons (the highest to the lowest) as follows: adverse event (DR1), withdrawal by subject (DR2), lost to follow-up (DR3), lack of efficacy (DR4), protocol violation (DR5), due to termination of the study (DR6), all other reasons (not provided) (DR7), criteria changes (DR8), incorrect randomization or enrollment (DR9), intake of prohibited medicine (DR10), physician decision (DR11), Abnormal lab value & contraindication outcomes (DR12). DR2 (withdrawal by subject) can be further classified as follows: family problems, change of health conditions, transportation problems, lack of motivation, interference with work, low remuneration, moving out, overnight stay, and pregnancy.

We also analyzed the participants in terms of their gender and age (shown on the top of each bar in Fig. 9).

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5 http://www.clinicaltrials.gov
10). The oldest study group is S5, with a median age of 75 and the youngest study group was S1 with a median age of 40. Study S6 has a high women-to-men ratio 75% vs. 25% while Study S2 has more men than woman, 40% vs. 50%.

In order to analyze the recruitment process for a clinical trial study, we analyzed an alcohol clinical research data and found the loss of potential recruits at each step of the research. As seen in Fig. 11, there are three “drop-off” points that are the phases between 1) one and two, 2) five and six, and 3) seven and eight, that are critical. However, we feel that this figure captures and displays the essential qualitative and rough quantitative elements of the recruitment process for neuroscience studies and the attendant problems that our prototype attempts to address.

5. Conclusions & Future Work

In this paper, we presented the MindFlow system to enhance the recruitment process of clinical trials. This system will offer a practical estimation and assessment for new clinical studies, as the need to recruit volunteers for a new study arises. We believe that potential subjects will find this system to be valuable in determining the feasibility and execution of workflow for clinical trials. In the future, the following aspects will be addressed i) building a shared repository for clinical trial research, ii) making use of semantic technologies to provide advanced reasoning and data mining capability, and iii) exploiting user profiling techniques to improve the matchmaking process of clinical trial systems.

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