Differences in Internet Usage Patterns with Stress and Anxiety among College Students

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***Abstract*—Stress and Anxiety negatively affect mental health and can lead a number of debilitating impacts to overall health and well being. In the recent past, adolescents are becoming increasingly afflicted with Stress and Anxiety. In this paper, we report our findings on a six-week study of 70 students at a college campus on associations between Stress and Anxiety with respect to Internet usage of students. Using Cisco NetFlow records, on-campus Internet usage of students was collected continuously and unobtrusively in a privacy-preserving manner. Using the Depression Anxiety and Stress Scale (DASS), students were separated based on normal scores and high scores separately for both Anxiety and Stress. Mann-Whitney U-tests revealed that there exists statistically significant differences in the mean values between the groups from the perspective of several Internet usage features. Students with high stress scores exhibit decreased *chat (octets, packets, duration)*, *total duration*, and *streaming duration* compared to the students with normal stress scores. Students with high anxiety scores showed an increased *mail duration* and decreased *peer-to-peer duration* compared with students with normal anxiety scores. The methods and results of this paper provide a framework for conducting similar studies at universities with the goal of aiding student mental health.**

***Keywords*—Stress, Anxiety, Internet, Mood Disorder, College Students**

I. Introduction

Stress and Anxiety disorders are among the most common mental health problems on campus colleges. A quantitative study by American College Health Association's (ACHA) National College Health Assessment reports in its Spring 2012 edition that 21.0% and 30.5% undergraduate students experience Anxiety and Stress, respectively [1]. The physical effects of excessive stress and anxiety are reduced immune system response, heart attacks, strokes, ulcers, and other gastrointestinal disorders [2]. Specifically, the stress produced by daily activities in the college life also results in physical ailments, psychological distress, and decreased academic performance.

While the physical effects of these disorders are often highlighted, the economic consequences are also alarming. According to "The Economic Burden of Anxiety Disorders", a study commissioned by the Anxiety Disorders Association of America, anxiety disorders cost the United States more than $42 billion a year, or almost one-third of the country's total mental health bill [3]. At the same time our usage of sedative drugs keeps increasing which costs the nation $300 billion every year in medical bills and lost productivity (between 1997 and 2004). Existing stress and anxiety disorder treatments are psychotherapy, antidepressants and benzodiazepines [4]. Since there is often very little basis to prescribe one treatment over another, the efficacy of treatments are often debated. Preventative treatment measures and distribution of educational materials may reduce the cost incurred of reactive medical treatments like intensive treatment and medication.

In recent years, a shift in the needs of students approaching counseling services is becoming more evident. College counseling services are increasingly reporting that students are seeking services for psychological problems [5]. Chronic stress and anxiety disorder may lead to depression, cardiovascular risk, and other serious diseases. Students may either acknowledge they need help, but do not seek mental health services; or they do not identify themselves as needing help [6]. Students may not know symptoms of stress/anxiety or are reluctant to admit anything is wrong. These qualities make instruction and treatment difficult since many students are not coming forward. Identifying students with symptoms allows health professionals to provide specialized instructional material and preventative treatment.

A number of studies have been conducted exploring the reasons for relationship between Internet usage, stress, and anxiety [7]–[10]. While these studies provide useful insights, there are some limitations in existing studies. Student Internet usage has been assessed by means of self-reported surveys, which provides limited information. Memories fade with time and can dilute the useful information obtain from self-reported studies. Inaccuracies may also be introduced from social desirability bias, as some students may not want to admit the amount of time they are online. Acquiring accurate characterizations of Internet usage require anonymized, unbiased, and unobtrusive collection methods. The observation of these characteristics may help identify students with needs for mental health professionals.

II. Present Study

In this paper, we report our findings on six-week study beginning late January 2013 and concluding at the end of February 2013 on 70 college students at Missouri University of Science and Technology on associating symptoms of Stress and Anxiety with Internet usage. The goal was to verify if there are discernible Internet usage features associating with increased or decreased symptoms of these disorders. To do so, we collected *real* Internet usage data *continuously*, *unobtrusively* and preserving *privacy* from campus networks, which to the best of our knowledge is the first study to do so.

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Assessing the stress and anxiety levels of participating students were achieved through the Depression Anxiety and Stress Scale (DASS) [11]. DASS was chosen for its consistent measures and psychometric properties. The recorded scores showed good internal consistency; Cronbach's Alpha value of 0.88 and 0.86 for stress and anxiety, respectively. Depression is not discussed in this study, readers are encouraged to read the authors' previous work regarding depression symptoms and Internet usage [12]. For stress and anxiety, students are separated into groups of *normal* scores and *above normal* score. To determine if any statistically significant Internet usage differences exist across the groups, Mann-Whitney U-tests are performed and the results are presented.

The results and procedures of this paper provide a framework for other institutions to perform similar studies. Additionally, the results of this paper and future research may provide incentive for mental-health-monitoring application development, based on Internet usage patterns.

III. Method

A. Participants

The study was conducted on the Missouri University of Science and Technology (Missouri S&T) campus in Rolla, Missouri. Students enrolled in Psychology 50 (General Psychology) were recruited for participation in this survey. The study consisted of 70 students, 16 of whom are female and 54 male. All 70 participants were students at the time of the study, aging from 18 to 35. This course is taken by students from several departments at Missouri S&T. Table I details the departments contributing the most students, while the remaining departments are aggregated under *Other*.

TABLE I. Summary of Student Participation

Department	Gender	Total	Stress > 14	Anxiety > 7
Arts, Languages, & Philosophy	M	0	–	–
	F	2	0	0
Biological Sciences	M	0	–	–
	F	5	1	0
Business and Information Tech.	M	5	1	1
	F	1	0	0
Chemical and Biochem. Engr.	M	3	1	1
	F	2	0	0
Civil, Arch., and Env. Engr.	M	2	0	1
	F	0	–	–
Computer Science	M	10	2	1
	F	0	–	–
Economics	M	1	0	0
	F	0	–	–
Electrical and Comp. Engr.	M	7	1	1
	F	0	–	–
Engr. Mgmt. and Systems Engr.	M	8	1	2
	F	3	0	1
Geological Science and Engr.	M	2	0	1
	F	0	–	–
History & Political Science	M	2	1	0
	F	0	–	–
Mathematics & Statistics	M	2	0	0
	F	1	0	0
Mechanical & Aerospace Engr.	M	7	2	2
	F	2	0	0
Mining & Nuclear Engr.	M	5	2	2
	F	0	–	–

B. Procedure

1) Surveying: The DASS survey was administered to an introductory Psychology class of 70 students near the beginning of the Spring 2013 semester. DASS was chosen as the goal of this study was to quantify stress and anxiety. It has previously been demonstrated that the DASS provides consistent, reliable results[13]. The surveys were immediately tabulated and stored using uniquely assign pseudonyms.

To ensure privacy of participants, appropriate anonymization techniques were enforced during participant selection, surveying and collecting Internet usage data. The IT department at Missouri S&T provided unique pseudonyms for each participant, and the associations were not disclosed to the research team. Students who completed the CES-D survey did so using only their pseudonyms, which were tied to their recorded CES-D scores. The IT department remained unaware of the CES-D scores. Additionally, the IT department provided the on-campus Internet usage data indexed only by pseudonyms. The only associations available to the researchers were between Internet usage data and CES-D scores. In our study, IP addresses were not processed, since the focus was on broad Internet statistics alone. Also, the contents of emails, chat and ftp uploads/downloads were not recorded due to privacy considerations.

2) Internet Data Collection: Once the surveys were tabulated and anonymized, data collection began by exporting Cisco NetFlow records. NetFlow is a solution for monitoring network and application resource utilization provided by Cisco networking hardware[14]. Network packets are stored as *flows*, which is a unidirectional set of packets with identical *source IP address*, *destination IP address*, *IP protocol*, *source port*, and *destination port*. Equivalently, flows are uninterrupted data streams from one computer to another. All campus Internet traffic passes through Cisco routers where data is subsequently stored, as shown in Figure 1.

It is important to note that *no traffic content* was analyzed or stored as part of the procedures. NetFlow does not contain the capability to do so and was not the aim of this survey. Instead, available data consisted of NetFlow Version 5 datagrams, detailing addresses and sizes of packets. The data is stored in a large database containing flow records as rows. An example set of exported flow records is shown in Table II. Identifying the set of flows belonging to a student requires *Dynamic Host Control Protocol (DHCP)* logs. DHCP manages IP address leases and records the IP address, start time, end time, and *Single-Sign On (SSO)* username associated with registered students for each lease. Each of these entries in the log file specify the time and duration a student used a

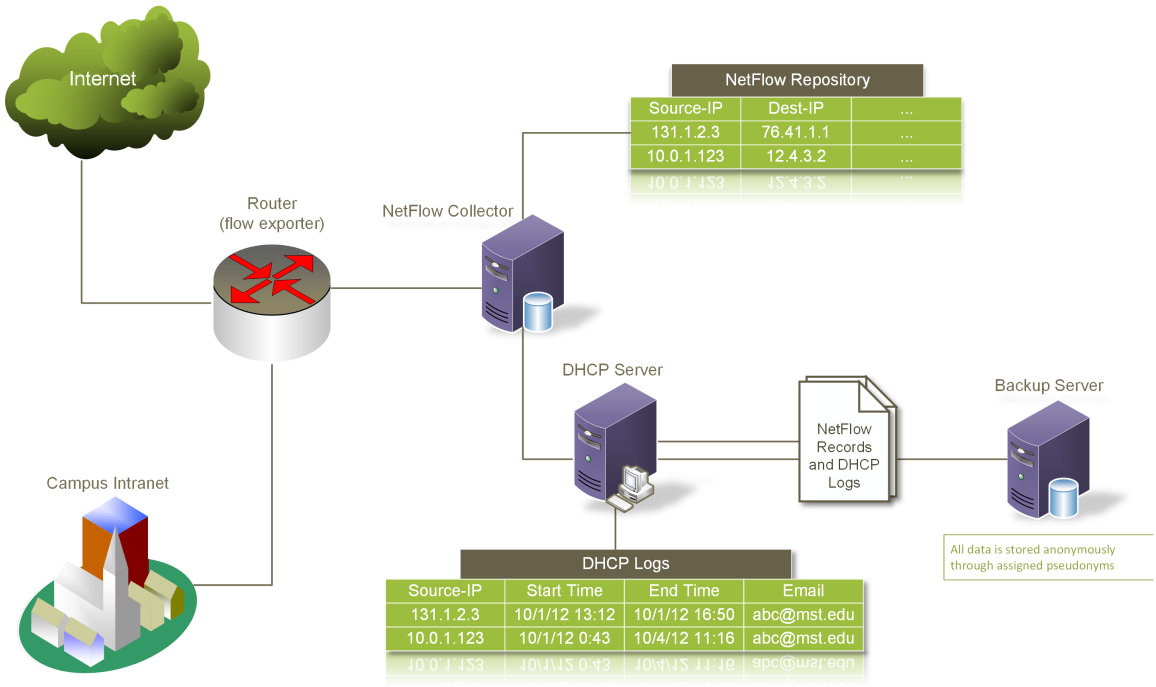

Fig. 1. Illustration of NetFlow Data Collection Process

TABLE II. SAMPLE NETFLOW DATA EXPORT

srcip	dstip	prot	srcp	dstp	octets	pkts	dur
131.151.x.x	208.78.x.x	6	65045	80	124	4	20
131.151.x.x	208.78.x.x	6	65053	80	1203	12	173
131.151.x.x	208.78.x.x	6	65082	443	1533	9	196

specific IP address. By matching the *source IP address* of flows with DCHP information, the user-specific NetFlow records are extracted and stored in an encrypted database. This process is performed for all participating students with their identities protected by pseudonyms and automated procedures.

3) Preprocessing: The raw NetFlow data must be transformed into more suitable representations that enable statistical analysis. To answer whether individuals with higher DASS category scores are more/less involved with Internet activities, aggregate representations of the data are used. The aggregate fields represent elements of an N-dimensional *feature vector*, used in the statistical analysis. The features calculated can be categorized as *Aggregates* or *Application* fields. *Aggregates* is the set of fields computed by the summation of observed flow *octets*, *packets*, and *duration*. Application features consist of the same flow record attributes, but are partitioned based on application categories shown in Table III. The latter features are useful for identifying unobserved characteristics in the aggregation of all flow data, such as a group of students engaging with specific application categories.

Since flow records do not contain application information directly, individual entries must be assigned to a category. The Internet Assigned Numbers Authority (IANA) maintains (*destination port*, *destination protocol*) pairs, which enables resolving well known port numbers to applications [15]. These allocations were used to further partition stored data sets by application type and reduce computational efforts by only selecting categorized flows. The preprocessing steps are important for reducing data storage and subsequent analysis, as NetFlow exports can easily contain millions of records. Furthermore, partitioning data produces manageable stores that simplify navigation for users and programs.

TABLE III. POST-PROCESSED APPLICATION GROUPS

Category	Applications
p2p	Peer-to-peer file-sharing applications (edonkey, neommodus, winmx)
http	HyperText Transfer Protocol traffic (HTTP, HTTPS)
streaming	Media streaming applications (shoutcast, real, winmedia, stream-works, audiogalaxy)
chat	Instant messaging and chat room applications (AIM, IRC, Carracho)
email	Email traffic (IMAP, POP3, SMTP)
ftp	File Transfer Protocol traffic (SNMP, FTP)
gaming	Online multiplayer games (BattleNet, Quake, Starsiege, DirectX, HalfLife, GameSpyArcade)
remote	Remote file system access (AFS, NFS)

4) Statistical Analysis: Students scoring in the *normal* range are assigned to the group G_N, while students scoring outside the *normal* range were assigned to the group G_H. In this context, G represents *Group* and the subscript represents which group; N and H for normal and high scoring groups, respectively. Furthermore, the subscript also states whether the group represents *stress* or *anxiety*. For each of these mental health disorder symptoms, a statistical test is performed to determine if one group has a statistically significant different mean than the other group.

The non-parametric *Mann-Whitney U-test* was used to determine statistically significant differences in the observed mean feature vector values between the two groups. This test was specifically chosen since the number of students belonging

to G_H is small and often violates the normality assumptions of many statistical tests. Results are determined to be significant under the null hypothesis that the mean values of separate groups are equal, or $H_\emptyset : \mu_N = \mu_H$. A significant difference in a sample mean value is determined by the rejection of $H_\emptyset$ at the chosen alpha of $\alpha = 0.05$. If the *two-tailed p-value* of a corresponding variable is less than α, then there is enough evidence to support the existence of a statistically significant mean differnce under the test. Two-tailed p-values are chosen as it is of interest to determine if one group uses certain features *more or less* than the other group.

IV. Results

A. Stress

Based on the reported DASS stress scores, students were partitioned into two groups, $G_{stress,N}$ for normal scores and $G_{stress,H}$ for high scores. 17.1% of the students scored above the *normal* range, resulting in $n_{stress,N} = 58$ and $n_{stress,H} = 12$. Performing Mann-Whitney U-tests revealed that the two groups has statistically significant differences in the mean values of *chatting (duration, octets, and packets)*, *streaming duration*, and *total duration*. The exact results are summarized in Table IV.

TABLE IV. Results of Mann-Whitney U-Test between $G_{stress,N}$ and $G_{stress,H}$ ($n_{stress,N} = 58$,$n_{stress,H} = 12$) for Stress

Feature	U(70)	P-value (2-tailed)	Z
Chat Duration	247.0	0.043	-1.57
Chat Octets	222.0	0.019	-1.96
Chat Packets	221.0	0.019	-1.98
Streaming Duration	231.5	0.035	-1.82
Total Duration	235.0	0.040	-1.76

B. Anxiety

Similar to the stress results, students were partitioned into two groups, $G_{anxiety,N}$ and $G_{anxiety,H}$. The number students belonging to each group were $n_{anxiety,N} = 57$ and $n_{anxiety,H} = 13$, leading to 18.6% of the students scoring outside the *normal* range. Performing the same statistical techniques, it was obtained that *mail duration* and *peer-to-peer duration* have statistically significant different mean values across the two groups.

TABLE V. Results of Mann-Whitney U-Test between $G_{anxiety,N}$ and $G_{anxiety,H}$ ($n_{anxiety,N} = 57$, $n_{anxiety,H} = 13$) for Anxiety

Feature	U(70)	P-value (2-tailed)	Z
Mail Duration	250.0	0.035	-1.81
Peer-to-Peer Duration	280.0	0.038	-1.34

V. Discussion

Our previous work, on analyzing negative mental health symptoms with Internet usage, we focused on Internet patterns with depressive symptoms [12]. The past study revealed that college students reporting depressive symptoms exhibited higher *chat*, *mail*, *peer-to-peer*, and *remote* usage. The students scoring higher for depression tended to use these application groups more. The results of this study show that students reporting normal levels of stress have increased *chatting*, *streaming*, and general Internet usage than higher scoring peers. Students reporting normal anxiety scores have demonstrated increased *mail* and decreased *peer-to-peer* usage. Comparing the results between our studies show that there is a complex dynamic involved between Internet usage of groups of students with and without negative mental health symptoms. Understanding the connections of these mental states and the role of Internet is an important task to pursue. The results of such studies could help health professionals obtain a metric for characterizing unhealthy Internet usage and its affect on the health of college students.

A. Interpretations of Stress Results

Common causes of stress among college students include changes in social activities, increased work loads, and studying for exams [16], [17]. With further inspection, the group of normally scoring stress students had larger mean values for *chat (duration, octets, and packets)*, *stream duration*, and *total duration*. A possible explanation for the outcomes is that online chatting and streaming media are effective stress reducers for college students. Chatting helps mitigate the effect of social stressors by allowing a student to communicate with peers and friends. The occasional break from academic duties by communicating with others may act as a stress reliever for many people.

The increased mean value of *stream duration* indicates that students with normal amounts of stress tend to listen to music more than their stressed peers. This has found to be an effective stress reducer when the music is self-selected [18]. As exams are large causes of stress among college students, allowing music-playing devices during proctored exams may benefit the mental health of students.

B. Interpretations of Anxiety Results

It was found that the mean values for *mail duration* for students scoring in the normal range of anxiety were statistically significantly different and lower than students with higher anxiety scores. Sources for anxiety among college students include desire to impress others, academic performance vs. expectations, and sleep deprivation [19]–[21]. The use of email communications allows socially anxious individuals to constantly review sent messages and meticulously craft emails. These qualities can lead to constant self-review and facilitate negative thoughts of ones perceived image.

The mean value of *peer-to-peer duration*, for the group of students with above normal anxiety scores, was found to be nearly zero. It is not immediately clear why this feature shows a statistical significance. One possible explanation is that students experiencing above normal anxiety levels view downloadable content as a distraction. If social contexts or academic work are causing the anxiety, the student may feel viewing downloaded content is wasting time.

C. Applications of our Findings

Although the study conducted in this paper is preliminary, it has got significant applications. At the outset, we have identified tangible Internet usage features associating with mood disorders. It may be possible that with more studies and

findings, we could design algorithms to intelligently search for specific Internet usage patterns that can proactively detect the onset or changes in mood disorders. We believe that such applications can significantly improve healthier lives of people, along with economic benefits.

Recently, there is an increasing interest in Computerized Cognitive Behavior Therapy, wherein therapies for human behavioral problems are done via the computer, or in some cases online. Integrating our findings with these applications will provide significant value to validate the efficacy of treatment along with cost savings.

D. Ethical Considerations

While this study was conducted with IRB approval [1], with consent of subjects, there are certain issues stemming from ethics of the proposed applications for this study. At this point, we believe that certain populations like children, who are increasingly afflicted with mood disorders, and who are also active Internet users may benefit, especially if parents can their monitor online usage. This is not a bad idea, and Law Enforcement agencies across the globe actively encourage parents to monitor their childrens' online usage considering the enormity of threats children face in cyber space today. As such, we may be able to detect mood disorders in children quite early. We also believe that certain elderly populations, and those that have limited resources to proper mental health care may also benefit from the study. Nevertheless, we are actively discussing with ethicists, counselors, clinical psychiatrists and psychologists to further discuss ethical and privacy issues arising from applications of the proposed study.

VI. Conclusion

In this paper, the findings of a six-week study to identify Internet usage differences between normal and above normal scoring groups for stress and anxiety. The procedures and methods for conducting this analysis were presented for researchers to enable similar studies at other establishments. It was demonstrated that for stress, students in the above normal group have statistically significant decreased in *chat (octets, packets, and duration)*, *streaming duration*, and *total duration*. For anxiety, it was found that the mean, *mail duration* and *peer-to-peer duration*, values of the above normal group was statistically significantly different than that of the normal group. Interpretations of the results were provided to benefit future research.

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[1] Exempt Category 4- "Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that participants cannot be identified, directly or through identifiers linked to the participants.

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