Thesis Portfolio

DCMPAA Student Registration and Database System
(Technical Report)

Synthesis of medical misinformation on search engines and social media before and during COVID-19
(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree
Bachelor of Science, School of Engineering

Amani Singh Vohra
Spring, 2020

Department of Computer Science

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Sociotechnical Synthesis

Internet has a tremendous presence and influence on today's lifestyle and business choices. This thesis considers two issues related to internet usage. The first topic is the technical report that relays the experience of the author helping a small business use technology to increase productivity. The author/developer paired with a small business, DC Metro Punjabi Arts Academy (DCMPAA) to identify need and constrains, research a software architecture, develop possible solutions, deploy a solution, evaluate and maintain performance. The author created a registration and database system.

The second topic is the STS research paper on internet components such as search engines and social media. While misinformation has been around forever, its velocity and volume have increased due to search engines and social media usage. This paper compares research studies, identifying motivation, methodologies, and results, before and during COVID-19 to reflect the current socio-technical problems and solutions identified to combat medical misinformation on social media and search engines.

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Signature  Date 4/27/2020
Amani Singh Vohra

Approved Nada Basit (nb3f) Date 4/24/2020
Nada Basit, Department of Computer Science

DCMPAA Student Registration and Database System

Small businesses struggle to automate processes and make them cloud accessible, leaving many processes to remain slow and on paper. Small business owners with no or little IT or software engineering experience fail to realize what can be automated and how to do so. The author/developer paired with a small business, DC Metro Punjabi Arts Academy (DCMPAA) to identify needs and constraints, research a software architecture, develop possible solutions, deploy a solution, and lastly evaluate to maintain performance. This project migrated physical records to an automated cloud platform to digitize data organization and tracking. The development of this project can be divided into two phases: Minimum viable product (MVP) and Final. The most rewarding process of this project was single handedly taking a product from ideation to production.

Phase: Minimum Viable Product

The MVP phase consisted of largely understanding the client's needs and implementing an initial solution before committing to strict architecture. The client, DCMPAA, is a dance academy of roughly 300 students across 4 locations with 10 instructors and 3 administrators. The academy teaches dance to students of ages 4 to 18. Prior to the project, DCMPAA took new student registrations on paper, had a non-standardized mechanism to take class attendance, and a manual non-PCI (Payment Card Industry Data Security Standard) compliant payment information storage. The primary needs of the client were an automated student registration process with a PCI compliant payment processor integration and an attendance mechanism on the cloud. While researching a possible software architecture, the main constraints the developer had to consider were financial constraints of a small business and the lack of software/ IT experience for the users (instructors and administrators). The developer looked into a variety of

database systems like Zoho, Caspio, Knack and Quickbase, however decided against using them due to high cost and advanced technical skill required to build and use them. Eventually the developer decided on an architecture using CognitoForms as the primary form for taking in new student registration, Microsoft Azure Logic Apps to perform integration between different platforms, and Google Sheets to store the data. Other than Google Sheets, the developer hadn't used any of these applications. CognitoForms is a form builder and was used to create the registration form. Microsoft Logic Apps creates logical flow without requiring any code by offering drag and plug in features. Logic Apps was used to transfer the data from Cognito Forms to the google sheets which housed the data for viewing and editing.

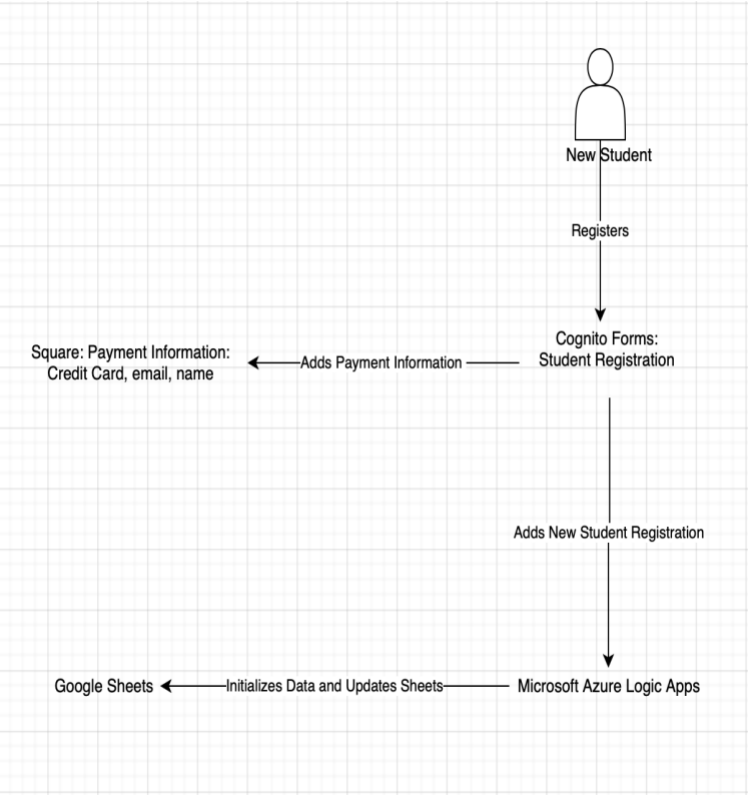


Figure 1: MVP Solution Architecture

As seen in Figure 1, the system takes new student registrations using CognitoForms (Figure 2) including payment information which is directly and only stored on the Square payment processor, processes data using Microsoft Azure Logic Apps (Figure 3) to generate records in Google Sheet (Figure 4). The total cost for this system is $25/month: $24/month for CognitoForms and roughly less than $1/month for Microsoft Azure. The google sheets included a master sheet to show all students information across all locations, as well as individual sheets per location for

class rosters (student information) and class attendance. All sheets included PAYMENT-ID, STUDENT-ID, and STUDENT NAME allowing any sheet to be related to another sheet creating a relational database of sorts. This MVP solution was tested throughout development and deployed to be used by the client.

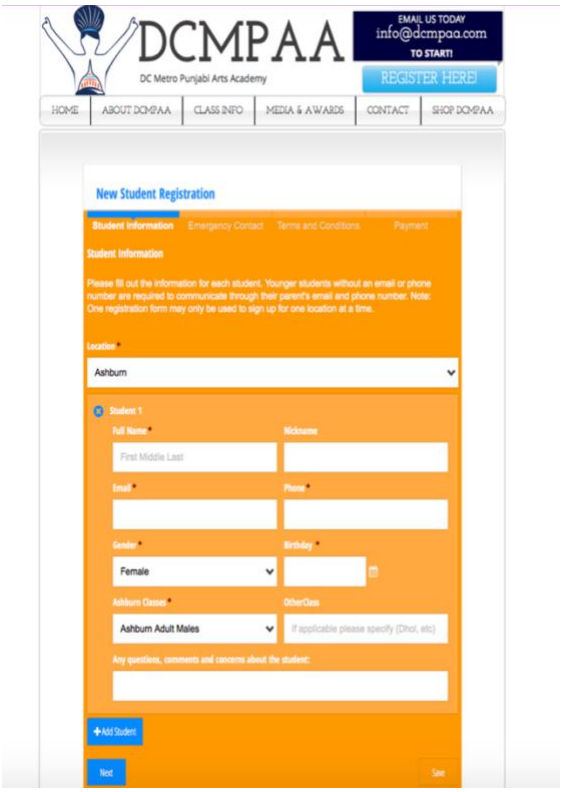


Figure 2: CognitoForms Registration Form

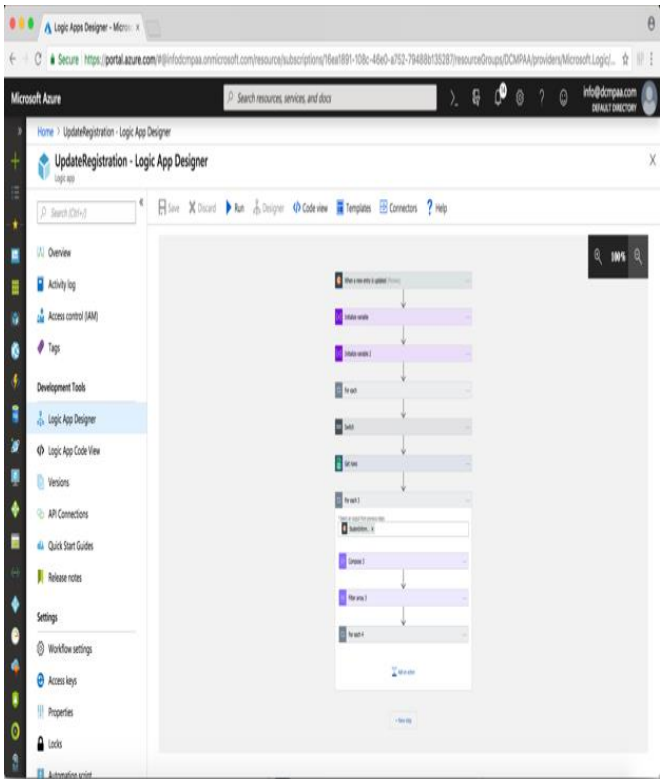


Figure 3: Microsoft Azure Logic Apps Higher Level Data Flow

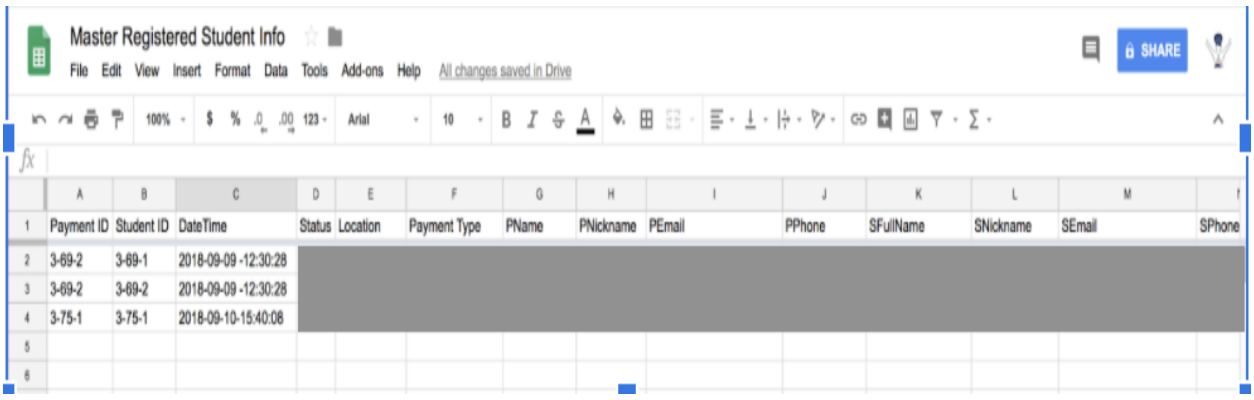


Figure 4: Master Registered Student Info Google Sheet. Data has been covered to preserve privacy

The MVP system worked well for the first year and had over 300 student registrations and was successfully used by 13 staff members. Issues included parents not officially registering their children as students causing staff members to informally add student names to the attendance sheets therefore having no record of them in Square in order to charge them or having the full student information. Other issues included administrators still having to manually bill parents for each student, however the credit information was now stored in Square who are liable for and provide application security. Lastly the largest issue that led to the demise of this system is that the code broke which led to no new student registrations being added to the google sheets. The reason for the code breaking hasn't been identified. It is hypothesized that new staff members were not being trained to use the attendance sheets and therefore changed the files names and/ or created new files causing Logic Apps to not find the designated file to add the new student data to. The other possible reason could be that Logic Apps was unable to successfully login into CognitoForms causing no data to be accessible to Logic Apps. Overall, the MVP solution was able to automate the student registration process and provide instructors with a cloud platform to take attendance and reflect real time changes. In addition to saving credit card information directly from the registration form into Square.

Phase: Final

Upon the code breaking in the MVP phase, it is understood that a more robust system needed to be developed. The system should not have been broken by the staff changing the files names. In addition, it is an extremely inconvenient way to do billing as the administrator would have to go sheet by sheet and manually add up the attendance for each student and then go to Square to charge them. The primary need for the client now is to have a user interface and with a database backend.

After researching, there were multiple chosen partial architectures that could be possible solutions: including 1) Wix website using Wix Data and Corvid by Wix to create a pseudo-database; 2) Azure SQL database with an Amazon EC2 web server; 3) Django website deployed on Heroku with Git to manage version control. Initially in order to capitalize on what had previously been done and use the client's website on Wix, the developer tried to implement solution 1, however quickly realized that this used very little code and required knowledge of Corvid which has drag and drop capabilities. As this solution wouldn't support the learning of further developing software engineering skills it was decided to try a different architecture. Solution 2 proved to have too many unknowns like how to have a database on the cloud, build a website and deploy that website. With no experience with any of the technologies in this solution architecture and given the timeline of providing a deliverable in less than one semester, this solution would be unlikely feasible. Hence as a result, solution 3 became the default option.

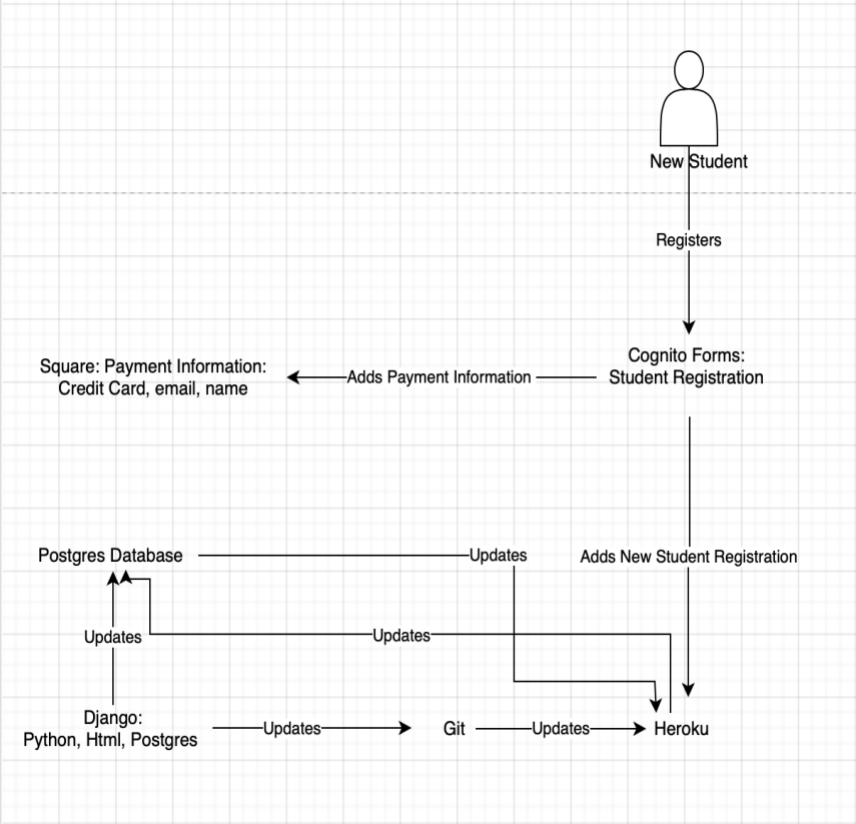
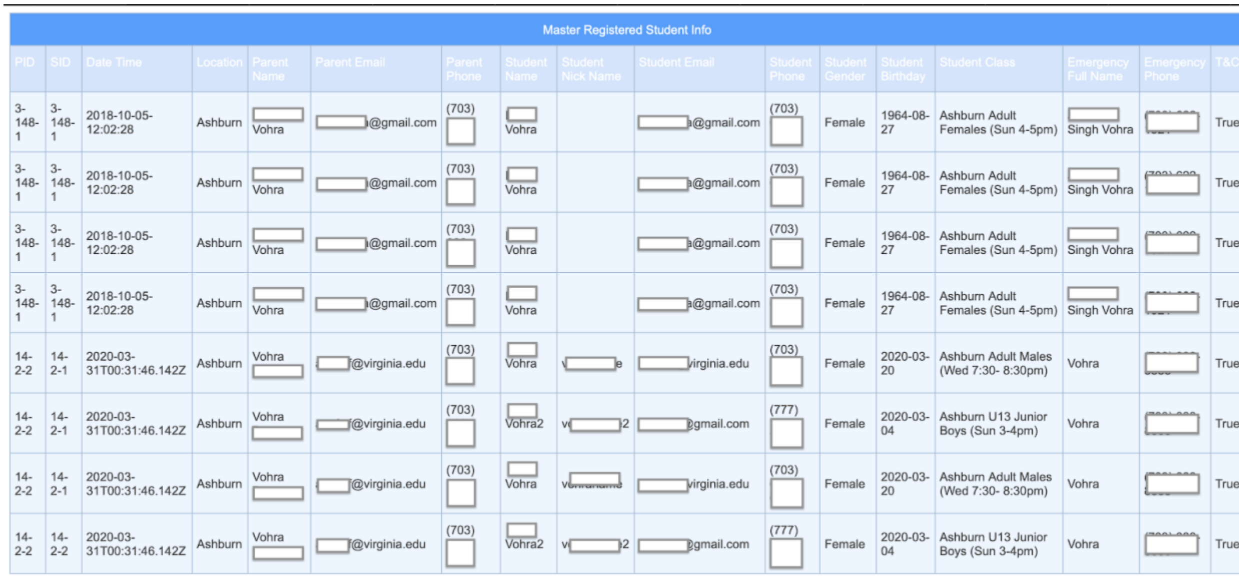


Figure 5: Figure 5: Final Solution Architecture

As can be seen on Figure 5, solution 3 required using CognitoForms as previously done, creating a website using Django with a Postgres database, deploying with Heroku, and using GitHub for version control during development. When a new student registers, CognitoForms sends form data upon a webhook on the Django website which parses the data and adds the data to the database which is displayed on the website itself as can be seen in Figure 6. Django web framework was chosen, as the developer had some experience with it and it supported the Model-View-Controller (MVC) pattern. MVC in Django was formed using Postgres, HTML/CSS, and Python. Postgres is an open-source relational database management system that will manage all the data the application is fed. This allowed the application to be easily controlled using a singular component instead of many. Django also offers admin and user interfaces and views which further simplifies the application for the developer. Heruko was chosen due to compatibility and plentiful documentation in how to deploy with Django. Heruko deploys the website on a web server so it can be viewed by anyone. Lastly GitHub, one of the most version control management platforms was used to track changes in source code during software development.



Master Registered Student Info

PID	SID	Date Time	Location	Parent Name	Parent Email	Parent Phone	Student Name	Student Nick Name	Student Email	Student Phone	Student Gender	Student Birthday	Student Class	Emergency Full Name	Emergency Phone	T&C
3-148-1	3-148-1	2018-10-05-12:02:28	Ashburn	[redacted] Vohra	[redacted]@gmail.com	(703) [redacted]	[redacted] Vohra		[redacted]@gmail.com	(703) [redacted]	Female	1964-08-27	Ashburn Adult Females (Sun 4-5pm)	[redacted] Singh Vohra	[redacted]	True
3-148-1	3-148-1	2018-10-05-12:02:28	Ashburn	[redacted] Vohra	[redacted]@gmail.com	(703) [redacted]	[redacted] Vohra		[redacted]@gmail.com	(703) [redacted]	Female	1964-08-27	Ashburn Adult Females (Sun 4-5pm)	[redacted] Singh Vohra	[redacted]	True
3-148-1	3-148-1	2018-10-05-12:02:28	Ashburn	[redacted] Vohra	[redacted]@gmail.com	(703) [redacted]	[redacted] Vohra		[redacted]@gmail.com	(703) [redacted]	Female	1964-08-27	Ashburn Adult Females (Sun 4-5pm)	[redacted] Singh Vohra	[redacted]	True
3-148-1	3-148-1	2018-10-05-12:02:28	Ashburn	[redacted] Vohra	[redacted]@gmail.com	(703) [redacted]	[redacted] Vohra		[redacted]@gmail.com	(703) [redacted]	Female	1964-08-27	Ashburn Adult Females (Sun 4-5pm)	[redacted] Singh Vohra	[redacted]	True
14-2-2	14-2-1	2020-03-31T00:31:46.142Z	Ashburn	Vohra [redacted]	[redacted]f@virginia.edu	(703) [redacted]	[redacted] Vohra	v[redacted]e	[redacted]virginia.edu	(703) [redacted]	Female	2020-03-20	Ashburn Adult Males (Wed 7:30- 8:30pm)	Vohra	[redacted]	True
14-2-2	14-2-1	2020-03-31T00:31:46.142Z	Ashburn	Vohra [redacted]	[redacted]f@virginia.edu	(703) [redacted]	[redacted] Vohra2	v[redacted]2	[redacted]gmail.com	(777) [redacted]	Female	2020-03-04	Ashburn U13 Junior Boys (Sun 3-4pm)	Vohra	[redacted]	True
14-2-2	14-2-1	2020-03-31T00:31:46.142Z	Ashburn	Vohra [redacted]	[redacted]f@virginia.edu	(703) [redacted]	[redacted] Vohra	v[redacted]	[redacted]virginia.edu	(703) [redacted]	Female	2020-03-20	Ashburn Adult Males (Wed 7:30- 8:30pm)	Vohra	[redacted]	True
14-2-2	14-2-2	2020-03-31T00:31:46.142Z	Ashburn	Vohra [redacted]	[redacted]f@virginia.edu	(703) [redacted]	[redacted] Vohra2	v[redacted]2	[redacted]gmail.com	(777) [redacted]	Female	2020-03-04	Ashburn U13 Junior Boys (Sun 3-4pm)	Vohra	[redacted]	True

Figure 6: Homepage for the deployed web application. Data has been covered to preserve privacy.

The developer was able to deploy a Django application with a Postgres database linking to CognitoForms with a webhook. This application maintains CognitoForms and Square compatibility as that portion of the architecture remains untouched. The Django application displays a homepage with all new student registration information like the master google sheet. The current database uses a singular table to house all student information. This architecture costs $24/month, solely due to the CognitoForms. This application has not been tested with users however shows promise in demonstrations of the system to client and research advisor. In the future, the data will be split into multiple tables to avoid redundant data and be linked with each other using PAYMENT-ID, STUDENT-ID, and/or STUDENT NAME. In addition, multiple web views will be developed to view only student(s), payment(s), class, location, attendance and billing information. Moreover, security will be added to the website by adding a login page to allow staff access only.

Synthesis of medical misinformation on search engines and social media before and during COVID-19

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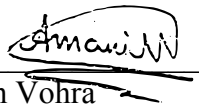
Signature  Date 4/27/2020
Amani Singh Vohra

Approved _____ Date _____
Richard Jacques, Department of Engineering and Society

Abstract

Misinformation is false or inaccurate information, especially that which is "deliberately promoted" and, or, "accidentally shared." Misinformation was listed by the World Economic Forum (WEF) as one of the main threats to our society. While misinformation has been around forever, its velocity and volume have increased due to search engines and social media usage. Search engines and social media are the commonly used online services allowing them to impact the amount and quality of information individuals receive significantly. At the time of this research paper, an outbreak of novel coronavirus (COVID-19) originating from Wuhan, Hubei Province, China, in 2019, has spread worldwide. (Smith, 2019) This paper compares research studies, identifying motivation, methodologies, and results, before and during COVID-19 to reflect the current socio-technical problems and solutions identified to combat medical misinformation. This research paper found that there are similarities and differences between studies on vaccines and previous pandemics, and COVID-19.

Synthesis of medical misinformation on search engines and social media before and during COVID-19

Introduction

Misinformation is false or inaccurate information, especially that which is "deliberately promoted" and, or, "accidentally shared." Furthermore, crisis misinformation is defined as, "false information about a crisis, initially assumed to be valid but can be later corrected or retracted, that can lead to factual misperception held by people." (van der Meer et al., 2020) Misinformation was listed by the World Economic Forum (WEF) as one of the main threats to our society. (Del Vicario, 2020) While misinformation has been around forever, its velocity and volume have increased due to search engines and social media usage. Search engines and social media are the commonly used online services allowing them to impact the amount and quality of information individuals receive significantly. (De Choudhury et al., 2014) To this end, it is imperative to reduce and prevent medical misinformation on these platforms due to the serious consequences inaccurate information can have. At the time of this research paper, an outbreak of novel coronavirus (COVID-19) originating from Wuhan, Hubei Province, China, in 2019, has spread worldwide. (Smith, 2019)

On January 23, 2020, the Chinese government ordered the city of Wuhan to quarantine; since then, many states and countries have declared a state of emergency and introduced strict social distancing measures. (Lopez et al., 2020) The COVID-19 pandemic has put a severe strain on many individuals, resources, and economies around the world. With social distancing and travel bans, people have taken to their devices, increasing their internet usage tremendously. (Chen & Ferrara, 2020) As internet usage increases so does the misinformation. Myths and hoaxes regarding the origin, possible treatments, and cures are widely spreading on the internet.

Medical misinformation can lead to serious, if not fatal, complications; therefore, it must be identified, understood, and combatted. This paper provides a deep dive into the literature about medical misinformation on before and during COVID-19. This paper compares research studies, identifying motivation, methodologies, and results, before and during COVID-19 to reflect the current socio-technical problems and solutions identified to combat medical misinformation.

Medical Misinformation in Vaccines and Pandemics Before COVID-19

Medical information shared on social media and found on search engines are from many sources of varying credibility with few to no moderator mechanisms in place. (Trethewey, 2019) Medical Misinformation is especially important to study due to its potentially dangerous nature to individuals and society. This section reviews some literature on medical misinformation regarding vaccines crisis, and H1N1 influenza, Ebola, and Zika pandemic.

The opinions affected by medical misinformation, once put on the internet, are tough to trace and change. There was widespread misinformation during the HIV epidemic, which can still be felt today in certain regions of the world. In the early 2000s, the Mbeki South African government denial of HIV and its treatment options left thousands of mothers without effective medical care. The Mbeki government promoted herbal remedies for AIDS, costing more than 300,000 lives.

In 2019, measles cases were the highest since 1994, according to the Center for Disease Control (CDC). The majority of these cases hadn't been vaccinated against measles. (Smith, 2019) This might be one of the most evident effects of viral medical misinformation. As seen, there can be dire consequences for individuals who reject medical advice due to misinformation on the internet. (Larson, 2018) Measles has seen a resurgence in cases due to "unfounded fears" about vaccines. (Collier, 2018) This can be traced to a single flawed study regarding the MMR

(measles, mumps, rubella) vaccine, which inaccurately asserted that the vaccine caused autism. (Hill et al, 2019) Though its publication has since been retracted; this belief continues to be propagated throughout the media, often by activists, celebrities, politicians, and bots fostering controversy and polarization. (Larson, 2018) Even more surprisingly, retraction showed to have limited effect in literature and scholarly circles. Another study found that despite retraction, a fraudulent article was cited 298 times. In the 8 years after retraction, the article was cited 85.9% positively and 8.4% negatively, with only 5.7% recognizing its retraction. (Granter & Papke, 2018) Despite search engines like google having prevalent information, retracted articles continue to gain citations spreading misinformation. (Couzin & Unger, 2006) Thus, once misinformation spreads, it's hard not only to control its spread but also its possible ramifications.

Beyond the individual prerogative, there is a study regarding vaccines, culture, and herd immunity. Herd immunity is, "…when a large percentage of a population has become immune to an infection, whether through previous infections or vaccination, thereby providing a measure of protection for individuals who are not immune." (Fine et al., 2011) This behavioral experiment presented an optimistic finding of the communication of herd immunity, causing an increased uptake in vaccine rates. (Reichel, 2019)

Understanding the impact of information on personal decision to vaccinate can best be seen during the H1N1 Influenza pandemic in Turkey. A study revealed that most health care workers in Turkey did not accept a vaccine; though they considered themselves at risk, they only deemed persons with "poor" immune systems at risk for severe illness and death. In denying the vaccines, health care workers failed to realize their role in potentially spreading the virus. It was found that people who didn't vaccinate against influenza received their news from the media, which promoted that the vaccine went through a fast-tracked authorization process. Whereas

those who did vaccinate relied on "evidence-based sources and accessed information from the guidelines of the Ministry of Health, Professional Medical Associations, and the World Health Organization." This study suggests that healthcare workers are also susceptible to misinformation. Hence it is essential to encourage them to use evidence-based information during their decision making. (Hidiroglu et al, 2010)

Furthermore, a twitter study archiving over 2 million tweets during the 2009 H1N1 Influenza pandemic classified 4.5% of tweets as misinformation. The study also showed increased twitter activity corresponding with major new stories breaking implicating tweets may be used for real-time content analysis to understand public sentiment and knowledge, proving health authorities could monitor and respond to public concerns simultaneously. (Chew & Eysenbach, 2010)

Though social media is a successful medium to share public medical information from authorities, it is also successful in spreading information. An analysis of Facebook content regarding the Zika virus pandemic found that misleading posts about the disease were more popular than those with accurate public health information. The most popular accurate post was by the World Health Organization (WHO), viewed 43,000 times, and shared 964 times. In contrast, the most popular misleading post was "10 reasons why Zika virus fear is a fraudulent medical hoax," which was viewed 530,000 times with 19,600 shares and 600 supportive comments. (Sharma et al., 2017) Misinformation during pandemics is counterproductive to public health measures trying to control the disease. Despite widespread misinformation, not all hope is lost. Correcting misinformation with a source has been proven to lessen belief in false information. Additionally, a complementary study found that misinformation corrected by the CDC alone, in contrast to an individual, on social media were able to reduce misperceptions in

the United States. Beyond social corrections, algorithmic solutions also show promise in correcting misinformation; in some cases, perhaps more promise than social corrections. (Reichel, 2019)

Likewise, a twitter study about Ebola prevention or cure found that 44% of these tweets were retweeted(shared). Of these retweets, 58.9% had medical misinformation, and 38.3% had accurate information, further corroborating that misinformation is shared more widely and gains a greater reach than medically correct information. (Oyeyemi et al., 2014)

Medical Misinformation during COVID-19

As of March 27, 2020, there were 2,971,669 cases of COVID-19 worldwide and 206,544 deaths, according to John Hopkins University. The pandemic currently has a 2% to 3% case fatality rate. (Oyeyemi et al., 2014) The pandemic is crippling economies and health care systems around the world. (Ingraham & Tignanelli, 2020) No single crisis has affected daily life around the world like this pandemic since World War 2. Currently, there are no preventive methods other than social distancing and quarantining. (Depoux et al, 2020) With social distancing in play, people have taken to their devices. Given the extent of the pandemic and increased internet usage, "online conversations could provide a rapid assessment of the spread and possible changes in public attitudes and behaviors (e.g. self-isolating, hand- washing, accessing health care), awareness about the disease and its symptoms, and the impact of important decisions taken during the outbreak (e.g. quarantine measures, development of new vaccines, internationally coordinated responses) on public perceptions and attitudes." (Depoux et al, 2020) Due to the large number of people affected by this crisis, an increased amount of misinformation is singularly targeted towards this crisis. (Waddell, 2020) WHO said it, not only, confronting a pandemic, but also an "infodemic." (Frenkel et al, 2020) The WHO Director-

General, Dr. Tedros also went on to say, "Misinformation on the coronavirus might be the most contagious thing about it." (Depoux et al, 2020) His statement implicates that misinformation could quicken the epidemic spread by negatively influencing and fragmenting public response if not combatted. (Cinelli et al., 2020)

As the pandemic persists, conversations about COVID-19 continue to increase. A study tracking the amount of conversation on Twitter was able to find a highly correlated spatio-temporal relationship between communication about the disease and new cases of COVID-19. The study found an information lead (refers to the tweets occurring before the cases) of 2 days for the US and 4-5 days for Italy and China. The study provides grounds for novel future opportunities for disease forecasting using social media. The study also found that most twitter conversations were about the virus itself, medically related information, or "global nature of the pandemic."(Singh et al., 2020) To that end, it is imperative to do content analysis on social media. Another twitter study tracking COVID-19 with hashtags of 673 tweets found that 70% of the tweets were about public health and, or, medical information. This study supported, studies from previous pandemics, that medical information is widely shared on social media. The study also found that 24.8% of the tweets contained misinformation, and 17.4% contained unverifiable information. Additionally, the misinformation was higher from informal individuals/groups than from verified Twitter accounts. Lastly, misinformation and unverifiable information were least likely tweeted from healthcare/public health accounts. Likewise, tweets with the hashtag 'COVID-19' (World Health Organization- recommended terminology) had the least amount of misinformation and unverifiable information, whereas the hashtag '2019_ncov' and 'Corona' had the highest. (Kouzy et al., 2020)

Beyond social media to get a deeper look at all content with misinformation, a study analyzed a sample from fact-checked claims in English between January, 20202 and March-end, 2020. This sample came from claims fact-checked by the International Fact-Checking Network (IFCN) and Google Fact Checking Tool. Between January and March, fact checks increased by 900%. This sample study found that 59% of the misinformation was a type of reconfiguration, "where existing and often true information is spun, twisted, recontextualised, or reworked." 38% of the sample was entirely fabricated, and no 'deep fakes' were found. Reconfigured content attributed 87% of social media interaction and 12% of fabricated content. 20% of these claims were made by public figures but accounted for 69% of social media engagement proving top-down dissemination. 39% of these false or misleading claims were about policies or actions from government and international organizations. (Brennen et al., 2020) This is doubly dangerous as not only are extremely public figures making inaccurate statements, they are also doing so by inaccurately referring to the actions and policies of trusted public institutions, giving a larger audience more believable misinformation.

Increased misinformation can also be caused by public panic due to lack of medical research about the preventative and curing measures for COVID-19. Though COVID-19 is a trending topic, no scientific quality (passed HONcode, JAMA, DISCREN criteria) information had been published by February 6, 2020. No scientific quality information is not to say that no information was available. There was plenty of information available on Google; however, none that met standards of medical(health) information. (Cuan-Baltazar et al, 2020)

Although there are no proven preventive measures and cures for COVID-19 (other than social distancing), myths and hoaxes continue to claim they do have answers. Similar to the Mbeki government's herbal treatments for HIV, unproven home remedies that cure or prevent

COVID-19 are rapidly spreading. Such remedies include taking vitamin C and eating garlic. While most remedies are generally harmless, those that use bleaching agents such as chlorine dioxide solution can be extremely dangerous. (Mian & Khan, 2020) Moreover, there has been significant noise regarding hydroxychloroquine treatment. As of March 25, there is no evidence that hydroxychloroquine is beneficial in treating COVID-19. However, a study published by Gautret et al. alluded to finding decreased viral load in patients with hydroxychloroquine despite it being an observational, non-randomized, methodological flawed, and clinically irreverent study. (Ingraham & Tignanelli, 2020) Since its publication, this study has trended on social media, and even a combination of hydroxychloroquine and azithromycin was peddled as "biggest game changers in the history of medicine" by the United States President Donald Trump. As a result, prescriptions for chloroquine and hydroxychloroquine have dramatically increased, causing medical authorities to caution doctors when prescribing them. (Rosenberg et al., 2020) There even have been fatal overdoses caused by the drug since this study's publication and this drug's publicity. These cases reflect the lethal consequences of spreading and believing misinformation.

Analysis

Studies reflected in this research paper show a variety of similarities and differences in the studies topics, motivations, and results before and during COVID-19. This paper did a document analysis of research papers about medical misinformation, particularly in pandemics. The document analysis included identifying research motivation, methodology, and results. Some of the main similarities are the scope of medical misinformation and people engaging with it. Medical information continues to be a hot topic on social media and search engines. Therefore, much of the research focuses on social media and search engine platforms. Much

research has gone into identifying the amount and type of misinformation. The research often focuses on understanding the diffusion of misinformation. Such researches explore how deeply and far misinformation is spread and to what extent the information is inaccurate. The content of the misinformation is also studied as well as its susceptibility. From the public to politicians, actors, and public institutions taking to the internet to converse about medical information, many research focuses on the source, and their reach is also studied to understand the breadth and depth of the spread. Research reveals that all people are susceptible to misinformation, including scientists; therefore, it is essential to remain vigilant and acquire and heed the advice of evidence-based research from trusted medical institutions. Professional and government opinions and policies continue to be varied, as seen in past pandemics.

Research across pandemics agree that the volume of medical misinformation on social media and search engines make it extremely challenging for "lay person to distinguish fact from fiction," and scientists to a lesser degree. (Trethewey, 2019) Besides, Studying misinformation matters because "Human behavior is influenced by people's knowledge and perception." (Geldsetzer, 2020) Researchers also agree that no single strategy is able to combat all misinformation. (Larson, 2018)

There are some differences between studies on previous pandemics and COVID-19. Previous studies often focused on the best way to correct misinformation generally using behavioral and social measures like corrective information types. Previous studies also often suggested possible grass-roots and platform solutions like encouraging people to report and refute misinformation and encouraging platforms to provide trusted entities with more visibility. In the current COVID-19 studies, many of these suggested solutions have been implemented and are being evaluated. Besides, misinformation hasn't been combatted at great of a degree across

all platforms. Many fact-checking websites have moved from a manual approach to an algorithmic one; however, they still lag due to a large amount of misinformation. Google now highlights the most credible information regarding the COVID-19 in red. Facebook labels as "public, newsworthy posts" as false as well as remove false posts. (Waddell, 2020) Twitter blocks verified users from using their accounts until they have removed false tweets. Public organizations such as WHO have created a TikTok to share information. (Oxford Analytica, n.d.) Lastly, scientific and academic institutions haven't ever come together in researching a singular crisis so quickly and deeply. (Ingraham & Tignanelli, 2020) So, while there are many similarities between researches, there are also many differences in the research before and during COVID-19.

Conclusion

This paper compares research between vaccines and prior pandemics to COVID-19. The paper compares research papers' motivation, methodology, and results. The analysis of these research papers found that there are multiple similarities and differences between the two categories. In both categories, medical information is widely shared and spread on social media and search engines, allowing for countless research opportunities. Many of the researches across pandemics focus on identifying the diffusion rate, scope, content, source, and severity of misinformation. Scientists also agree that the sheer volume of misinformation makes it hard for a layperson to distinguish misinformation and fact-checkers to correct it. Lastly, data shows that everyone is susceptible to misinformation, including scientists. On the other hand, there are some differences across prior pandemics and COVID-19. Many of the previous studies' suggestions regarding possible solutions are now implemented and evaluated during COVID-19. Due to the large scale of the current pandemic, like never before have, academic and scientific institutions

have begun researching on a singular topic so quickly. Limitations for this paper include time, money constraints, and lack of standardization in methodologies in the studies between and across pandemics. Future research directions for this paper include a deep dive into evaluating a singular solution being implemented to combat COVID-19. With that in mind, it is up to everyone to remain vigilant when getting information from search engines and social media. Misinformation can be found on every platform and needs tackling from many angles. Misinformation isn't and can't be combatted using a single solution. Lastly, it is essential to remember that medical misinformation is extremely dangerous and can have serious consequences.

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Prospectus

Life Cycle Analysis of Electric Scooters and Bicycles
(Technical Topic)

Mass Adoption of Electric Scooters and Bicycles
(STS Topic)

By

Amani Singh Vohra

February 2019

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

Signed: Amani Singh Vohra

Technical Advisor: _____

STS Advisor: _____

Starting December 2018, Bird and Lime, were given permits to have their electric scooters be used on public roads in Charlottesville. For a small fee, these fleet of scooters provide the public transportation from point A to point B. These electric scooters can be located and accessed using mobile applications for individual transportation. Currently U.S roads and public infrastructure is unable to handle these new vehicles due to the lack of regulations. The lack of regulations also means that there aren't safety standards to abide to. Furthermore, due to their dock-less nature, they can be parked anywhere, leading many to get vandalized. While these companies are able to produce more scooters and still make a profit, the sustainability of this practice can be questioned as electric bicycles and scooters are marketed to be extremely sustainable solutions for everyday transportation. In 2017, the global electric market was valued at $16.3 billion (Voltage, 2017), similarly the electric bicycle market was valued at $15 billion in 2016. (Statista) With rising demands, these markets are said to be only in their infancy with enormous projected growth for the future. As the industry grows and micro-mobility electric vehicles become available to early adopters, it is important to understand the technical and social impacts of their technologies. To understand the technical impact, a life cycle analysis of electric scooters and bicycles will be studied. As for the societal impact, mass adoption of electric scooters and bicycles will be studied. The safety and sustainability of these vehicles can cause changes in the rate of adoption. These products, marketed as every day sustainable transportation, must be analyzed on the merits of their safety and sustainability as well ease of adoption by individuals and institutions.

The technical thesis will address a life cycle analysis of electric scooters and electric bicycles, specifically claims of promoting it as sustainable and safe. Sustainability is a huge issue due to climate change and must be battled on all fronts. One of these fronts is transportation due

to the large amount of Carbon Dioxide (CO2) emissions produced by cars. Electric vehicles provide a sustainable alternative as they produce little to no CO2. In addition, to examining their environmental sustainability, consumers, businesses, and the government must also in account for their economic sustainability. Are electric scooters and bicycles truly sustainable? Are they truly safe?

I'll be considering study sponsored by European parliament on the life cycle analysis of battery powered electric vehicles to understand their life cycle emissions. (EU TRAN, 2018) Moreover, I'll be analyzing environmental and economic sustainability in pro-E-bike Italian pilots. This case study reports the performance of electric bicycles and electric scooters delivering of goods in urban areas by recording the vehicles' environmental, financial and social impacts and effects. (Nocerino, et al, 2016) I'll also be accounting for public perception of these vehicles using the discussion, *Are electric scooters promoted on social media with safety in mind? A case study on Bird's Instagram*? (Allem, Majmundar, 2018) Lastly, I'll also be considering an op-ed by a UVA alum, *The Electric Scooter Fallacy: Just Because They're Electric Doesn't Mean They're Green* to gauge their sustainability. (Chester, 2018)

While these vehicles may prove to be sustainable they first have to be safe for the public to use. Majority of the vehicles in the market are part of the private sector, however, all of these use public infrastructure such as roads, sidewalks, and parking lots. Therefore, while private companies are liable for the safety features of the individual product, the public and government is in charge of providing a safe public space to use these vehicles. I'll be examining safety policies concern as outlined in the comprehensive paper, *E-bikes in the Mainstream: Reviewing a Decade of Research* (Fishman, Cherry, 2016). The paper points out that data and research for two-wheel electric vehicles is in its elementary stages. I'll also be considering reports by news

agencies such as CITYLAB, about the *Anatomy of an Electric Scooter Crash* (Holder, 2019) and a UCLA study that tracked electric scooter injuries for a year (Trivedi, Liu, 2018). By analyzing research studies and media articles, one can better understand the sustainability and safety of electric scooters and bicycles.

The STS Thesis considers the adoption of electric scooters and bicycles using document analysis. Understanding adoption of a micro-mobility vehicle such as electric scooters and bicycles will allow us realize how future vehicles may diffuse in society. Increasing adoption of a sustainable alternative transportation can significantly curb emissions and push society towards a more environmentally resilient future. It is especially important to understand the difference in adoption between developed and developing countries in different parts of the world. The thesis will address causes of the greatest increase and decrease in their rates of adoption using actor network theory across the world in urban and rural areas. At a high level, actor-network theory identifies relevant social groups and things, and the interactions between them. In theory, everyone and thing can both be an actor and a network concurrently where all actor-networks are equal in power. In addition, it considers the interaction between actors and networks with microsocial and macrosocial lenses. Therefore, the theory is able to consider the sociotechnical implications of a technology at all levels and aspects like cultural, organizational, and technical. Categorizing actors and networks, and their interactions will identify which groups help and hinder adoption within society.

By analyzing different researches, one is able to pick out different actors and networks to evaluate. Here are a few studies and analysis. I'll be considering a qualitative research study on the adoption of e-scooters in urban environments. The study is user centered, and provides travel diaries, pre- post surveys, and evaluated usage and attitudes of users. The study found that

charging infrastructure must be well developed for high adoption and that weather conditions, safety, and baggage capacity were barriers to adoptions. (Hardt, Bogenberger, 2019) In this case, the network contains the user, charging infrastructure, and a number of non-living actors that effect adoption. To further understand users, I'll be using a survey study of early adopters. This study provides me valuable insight on which network that a user is part of is best fit for electric scooters and bicycles in terms of demographics and use cases (as in trip purpose: leisure or transportation for work). (Wolf, Seebauer, 2014) I'll also be considering the mode of communication used to increase diffusion using an empirical study on the interpersonal diffusion. (Seebauer, 2015) In this case, users, non-users, and their interactions are analyzed to predict adoption. This study is valuable in teaching companies how to increase adoption. This study provides insight on how an individual implicitly and explicitly aided and or empowered by a company can increase adoption.

Electric companies and governments are also important stakeholders to analyze within the network. The harsh pushback electric scooter companies have received by infiltrating cities, is best understood through media articles. A verge article documents how government officials are imparting regulations for these new technologies. (Hawkins 2018) Similarly, a Bloomberg article provides recent time sentiment on adoption of electric scooters by governments and how it compares with adoption of peer-to-peer car transportation, Uber. (Brustein, 2018) These articles are essential to understand private and public actors and their interactions. In discovering key actors and networks and their interaction one can understand mass adoption of electric scooters and bicycles within society.

In conclusion, together the technical and STS thesis are aimed to understand the integrity of electric scooters and bicycles in regards to their safety and sustainability for increased

adoption by individuals and society. The technical paper is a life cycle analysis taking in account sustainability and safety. The STS thesis is a document analysis using actor network theory to understand diffusion of these technologies in society. It's imperative to consider both the technical and societal effects of these technologies as they go hand in hand. Increased safety and sustainable increase adoption. And with increased adoption, responsible innovations must be safe and sustainable!

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