



ST. MARY'S
UNIVERSITY

Digital Commons at St. Mary's University

McNair Scholars Research Journal

Student Scholarship

Fall 2020

McNair Scholars Research Journal Volume XIII

St. Mary's University

Follow this and additional works at: <https://commons.stmarytx.edu/msrj>

Recommended Citation

St. Mary's University, "McNair Scholars Research Journal Volume XIII" (2020). *McNair Scholars Research Journal*. 13.

<https://commons.stmarytx.edu/msrj/13>

This Book is brought to you for free and open access by the Student Scholarship at Digital Commons at St. Mary's University. It has been accepted for inclusion in McNair Scholars Research Journal by an authorized administrator of Digital Commons at St. Mary's University. For more information, please contact egoode@stmarytx.edu, sfowler@stmarytx.edu.

The St. Mary's University
McNair Scholars Program

RESEARCH JOURNAL

Fall 2020 Volume XIII

The St. Mary's University
McNair Scholars Program

RESEARCH
JOURNAL

Fall 2020 Volume XIII

ST. MARY'S UNIVERSITY



One Camino Santa Maria
San Antonio, Texas 78228

www.stmarytx.edu

A Catholic and Marianist Liberal Arts Institution

What a long, strange summer it has been! This summer, twenty-three McNair scholars representing the College of Arts, Humanities, and Social Sciences; the Greehey School of Business; and the School of Science, Engineering and Technology at St. Mary's University forged a new path by completing our first-ever virtual research experience. More than any previous McNair cohort, these scholars gained important new skills as they mastered not only their individual research topics, but also a wealth of new technologies. During a typical summer, scholars are secluded together on campus, living in a community and supporting one another in frequent daily interactions in seminars and laboratories. This summer, scholars were living off campus at locations across the state, country, and internationally. The person in the next room was not another scholar, struggling with the same time constraints and tasks, but a parent, roommate, sibling, or grandparent who may not have understood what the scholars were trying to accomplish. Despite the challenges and distractions, these scholars excelled, proving themselves intelligent, motivated, creative, and resilient. Although we can hope we will never find ourselves forced into a summer like this again, the lessons and triumphs of this experience will serve our scholars well in the coming years as they confront life's unexpected challenges. Please enjoy these fruits of a very productive, albeit very unusual, McNair Scholars Summer Research Experience.

Dr. Jennifer Zwahr-Castro
Director, St Mary's University McNair Scholars Program

TABLE OF CONTENTS

Andrew Arizola.....	1
Andrew Magee.....	27
Angela Perez.....	45
Angelica Rabago.....	58
Brandon Ichavez.....	66
Sequoia Callahan.....	74
Eric Ortega Rodriguez.....	89
Elysandra Solis.....	101
Gissella Lara.....	123
Jessica Flores.....	132
John Sanchez.....	147
Micaela Cruz.....	154
Maralba Perez.....	170
Nicolas Fabbri.....	182
Regina de la Parra.....	194
Sarah Diaz.....	212
Wendy Ornelas.....	219
Zoe Vanover.....	233
Camryn Blackmon.....	248

“When they have us in the detention centers, they tell us ugly things and they bully us”: American rhetoric on immigration

Andrew Arizola

Mentor: Meghann M. Peace, Ph.D.

St. Mary’s University, San Antonio, TX

For many decades, Central American children and adults fled from their home countries to have a better life. Violence and corruption are the most common reasons why Central Americans left their home countries (Astorga-Morales, 2017). The Obama administration implemented a few policies to help the citizens of Central America. Essentially, the Obama administration proposed and passed a 750--million--dollar proposal to combat the violence in Central America. (Margesson, 2016). Recently, the Trump Administration implemented the Migrant Protection Protocol. Basically, migrants have to remain in Mexico until their case is heard, but while they stay in Mexico they lack hygiene products, and basic humanitarian protection (“Migrant Protection Protocols,” 2020). This study was conducted to see how Americans speak on immigration, specifically immigration from the south. The participants in the study consisted of 11 Republicans and 29 Democrats. The participants are either political figures, public figures, comedians, actors, or activists. 17 of the participants were women and 23 were men. I collected one comment from each participant, posted to platforms such as Twitter, news articles, and interviews in regards to immigration from 2010 to 2020. The results illustrated that not everyone aligns 100% with their political party at every issue. Interestingly, more women support immigration than men do. Also, national security was one of the main reasons why people are against immigration. The results were for the most part consistent with what many say about immigration. It is a realization that people today still think that immigration causes harm to America. In reality, this is a call to action that people should recognize the truth of immigration vs. commonly-held perceptions, and contribute to the cause. Positively, there are many people with huge platforms that support immigration and continuously fight for the rights of immigrants.

Introduction

Central Americans choose to leave their country of origin to flee the danger of brutal violence, economic disparity, and lack of opportunity (Astorga Morales, 2017). Central Americans have been facing these hardships for many years and continuously have to live their lives on edge. Many Central Americans choose to migrate to the United States for a better future for them and their children. But American's – specifically, the American government's policies– have made it nearly impossible to allow migrants from Central America to live the American dream.

In this study, I collect data—comments on immigration—from participants, who are famous and popular in America, from different industries that I find on Google searches from 2010 to 2020. I sort the data in different categories, using a thematic analysis to look for specific patterns and focusing specifically on how American political figures, public figures, comedians, actors, activists, and influencers talk about immigration in the last 10 years.

Literature Review

During the 1980s, civil wars in the Northern Triangle region, which is the region where Honduras, El Salvador, and Guatemala are located, were a major factor driving Central American migration to the United States. Displacement, economic instability, and insecurity were the results of the civil wars in Central America (O'Connor et al., 2019). Central Americans chose to leave their country of origin to flee the danger of brutal violence, economic disparity, and lack of opportunity (Astorga Morales, 2017). In a study that examined Central Americans' experiences, 234 adult Central American migrants to the United States stated that 32.2% of participants had a family member that was murdered, 45.4% received death threats, and 51.9% of the participants' family members received death threats (Keller et al., 2017). Other common reports were that 33% of participants experienced extortion and 29% were victims of domestic violence (Keller et al., 2017). For instance, a

migrant from Central America stated, “The reason why I fled my country is because of the safety of my life. I suffered domestic violence and my life was also threatened because of my partner” (LaRock, 2020).

An additional factor motivating Central American migration is the Mara Salvatrucha (MS-13), a malicious Central American gang which originated in Los Angeles, California. The gang began to rapidly expand due to the importance of territory. Moreover, the gang disciplined their members to fight for their territory, punished those who tried to leave the gang, confronted law enforcement and their families, and punished those who decided to disobey their orders. After the gang expanded, Californian authorities noticed the rise in gang activity in the state. Californian laws became harsher on gang members and started to increase prison sentencing and deportation for gang members who were natives of Central America. The gang members took the skills they learned in prison and applied it to their lives outside of prison. From 2001 to 2010, approximately 121,899 gang members were deported to the Northern Triangle (Dudley & Silva Ávalos, 2019).

After the members of MS-13 were deported, in 2012, approximately 54,000 members flooded into the Northern Triangle of Central America (Margesson et al., 2016). In that region, there was a rise of gang-related homicides during the mass deportation of Central Americans (LaRock, 2020).

As a result of these and other stressors, both children and adults from Honduras, Guatemala and El Salvador suffer from mental disorders such as PTSD and major depressive disorder, and they also suffer from threats of violence, actual violence, murders, sexual violence, extortion, and kidnapping (Keller et al., 2017). Essentially, a study of 234 Central American immigrants was conducted in McAllen, Texas, and the results showed that 45.4% of the adults had personally received death threats and 51.9% said that their family received death threats. Moreover, 33% of adults in the study suffered traumatic extortion experiences (Keller et al., 2017). A migrant from Honduras who

wrote a statement at a Nuevo Laredo, Mexico, shelter asserted, “I fled my country because they killed my daughter’s father and now they keep following us and they want to kill us because of some debts he left before he died” (LaRock, 2020). As a result of the trauma and violence they face, migrants decide to flee their home countries. Not all migrants who flee are adults. A study conducted 30 years ago found that perhaps between 10,000 and 20,000 undocumented children under the age of 18 enter the United States annually (Rodriguez,-et al., 1990) and a more recent study places the figure at more than 38,000 unaccompanied children migrants, who were apprehended at the southern border in 2018 (O’Connor et al., 2019).

The current President of the United States, Donald J. Trump has implemented policies that are meant to limit the amount of Central American migrants that come into the United States. For instance, the current administration’s enforcement of the new policy “Migrant Protection Protocol” (MPP) was intended for migrants to stay on the other side of the American

border. In fact, the Department of Homeland Security stated, “illegal individuals may be returned to Mexico and wait outside of the U.S. for the duration of their immigration proceedings, where Mexico will provide them with all appropriate humanitarian protections for the duration of their stay” (“Migrant Protection Protocols,” 2020). The Department of Homeland Security is making false claims to cover up the reality of immigrants seeking asylum. Evidently, as of November 2019, more than 2000 immigrants awaiting trial were residing in tents without water and electricity in Matamoros, Mexico (“Policies affecting asylum seekers,” 2020), clearly lacking humanitarian protections promised by the Department of Homeland Security. The migrants have been victims of violence of all kinds, and awaiting trial in Mexico has caused further violence and kidnapping in the camps in Mexico (Mueller, 2019). MPP is not the only attack on immigration perpetuated by the Trump Administration. The “Zero-Tolerance Policy” is a law that

jails migrants who try to enter the country illegally. This policy caused many parents to be separated from their children with no explanation (Hildreth, 2019). Lastly, during the first two years of President Trump's term immigration changed completely. In 2018, the Trump Administration began to limit the amount of Central American asylum seekers who tried to cross into the United States. Asylum seekers did not know how much time they had to wait.

Sometimes it was days, weeks, or even a few months before their hearings (Pierce, 2019).

For decades, Americans have had strong opinions on many political and social issues, but in the last 10 years, immigration has become an issue that everyone talks about. The opinions are good or bad comments about the beliefs and values that people hold tight. These opinions are from people in different industries from all over the United States. In this study, I am going to show how American political and public figures talk about immigration in the last 10 years.

Methodology

Participants and data

The data selected for analysis came from interviews and social media posts from 27 United States political figures such as current and former presidents, senators, and members of the House of Representatives. These politicians are currently serving or have served in the last 10 years. The politicians selected were those that are most popular and who strongly voice their opinion on television, YouTube, and social media. Table 1 shows the political figures included in the analysis, their political position, their party, their gender and the platforms and media in which their comments appeared.

Table 1: Political Figures and Affiliation

<u>Figure</u>	<u>Position</u>	<u>Party</u>	<u>Gender</u>	<u>Media</u>
Donald J. Trump	Current President	Republican	M	MSNBC
Barack Obama	President	Democrat	M	CNN
George W. Bush	President	Republican	M	CBSN
Joe Biden	Vice President	Democrat	M	CNN
Beto O'Rourke	Representative	Democrat	M	Twitter
Nancy Pelosi	Leader of the House of Representatives	Democrat	F	PBS NEWS
Julian Castro	Secretary of House	Democrat	M	MSNBC
Joaquin Castro	Representative	Democrat	M	C-SPAN
Mitt Romney	Senator	Republican	M	NBC NEWS
Cory Booker	Senator	Democrat	M	Twitter
Susan Collins	Senator	Republican	F	Personal Website
John Cornyn	Senator	Republican	M	Personal Website

STMU-MSRJ

Ted Cruz	Senator	Republican	M	Personal Website
Lindsey Graham	Senator	Republican	M	FOX NEWS
Kamala Harris	Senator	Democrat	F	Kamalaharris.org
Amy Klobuchar	Senator	Democrat	F	ABC NEWS
Mitch McConnell	Leader of the Senate	Republican	M	NEWSY
Marco Rubio	Senator	Republican	M	House.ontheissue.org
Charles Schumer	Senator	Democrat	M	Ontheissue.org
Elizabeth Warren	Senator	Democrat	F	Presidential webpage
Bernie Sanders	Senator	Democrat	M	POLITICO
Alexandria Ocasio-Cortez	Member of the House of Representatives	Democrat	F	SKY NEWS
Kevin McCarthy	Member of the House of Representatives	Republican	M	Kevinmccarthy.house.gov
Ayanna Pressley	Member of the House of Representatives	Democrat	F	Pressley.house.gov

Rashida Tlaib	Member of the House of Representatives	Democrat	F	NOWTHIS News
Ilhan Omar	Member of the House of Representatives	Democrat	F	Omar.house.gov
Hillary Clinton	Secretary of States	Democrat	F	CNN

Interviews and social media posts were also collected from 13 public figures such as celebrities, artists, and activists who speak on immigration. These data were taken from Twitter, YouTube, news articles, and interviews from CNN, MSNBC, C-SPAN, NOWTHIS news, Politico, ABC, NBC, and many other sources. Other posts are from celebrities who uploaded videos of themselves speaking on immigration policies that the Trump Administration implements. The celebrities I chose are influencers that go behind a camera quite often to voice their opinions in regard to immigration in the United States. Also, these celebrities made these comments in the past five years. The participants were chosen based on their popularity and openness of speaking on immigration issues. Table 2 shows the public figures included in the analysis, their role in society, their gender, their party, and the platforms and media in which their comments appeared.

Table 2: Influencers and Affiliation

Figure	Role	Gender	Party	Source
Cristina Jiménez	Activist	F	Democrat	Time.com

STMU-MSRJ

Selena Gomez	Artist	F	Democrat	Instagram
Chrissy Teigen	American Model	F	Democrat	Twitter
John Legend	Artist	M	Democrat	Twitter
Nicki Minaj	Artist	F	Democrat	Twitter
Kanye West	Artist/ Business	M	Republican	Twitter
Kim Kardashian West	Media/ Business	F	Democrat	Wmagazine.com
Cardi B	Artist	F	Democrat	ABC News
Gregg Popovich	NBA Coach	M	Democrat	Sportingnews.com
Ellen Degeneres	American Comedian	F	Democrat	Time.com
Jim Carrey	Actor	M	Democrat	Time.com
Jimmy Kimmel	American Television Host	M	Democrat	Time.com

Chris Cuomo	American Television Journalist	M	Democrat	Huffpost.com
-------------	--------------------------------	---	----------	--------------

Analysis

Each comment made by a political or public figure was coded in the following manner – that platform on which the comment appeared, whether or not support was expressed for immigration, the reasons for it, and whether or not the comment aligned with party values. A thematic analysis revealed patterns in the ways in which political and public figures have spoken about immigration during the past five years. For instance, John Cornyn stated that “we must take immediate action to secure our borders and to fix our broken immigration system” (Cornyn.senate.org). Cornyn expressed opposition to immigration. The theme present in his comment is that he believes that immigration is a threat to America’s national security. His comment aligned with the political values of his Republican party.

Results

The participants in the research that I conducted consisted of 11 Republicans and 29 Democrats. Additionally, 17 of those political figures, public figures, activists, comedians, and influencers were female and 23 were male.

Most of the participants of either party were in support of immigration. 33 participants were in support of immigration while 8 were against immigration. Please notice that the numbers are a little over the number of participants. This is because one part of a participant’s comment was coded as being for immigration and one part was coded for being against immigration. For instance, Susan Collins said, “fully fund the President’s border security initiative—including his wall, technology, more personnel—and provide a pathway to citizenship for the DREAMer population, those young people who were brought to America through no decision of their own.”

One aspect I looked at was those participants who aligned with their political party values and those who did not. Democrats

are overall supportive of immigration, in terms of offering a path to citizenship to those immigrants with no criminal record and who have been in the United States for more than five years. Republicans are more likely to be against amnesty for any undocumented immigrants regardless of their criminal record and are strong supporters of securing the border (Diffen.com). Additionally, 82% of Republicans tend to support their party’s beliefs about immigration (Diffen.com).

More than 25% of the male participants were against immigration. These participants are Donald Trump, John Cornyn, Ted Cruz, Lindsey Graham, Mitch McConnell, Marco Rubio, and Kevin McCarthy. These participants are Republicans and fully align with Republican values. Table 3 shows all participants against immigration as well as their reasons for being against immigration, using Durand (2017)’s three reasons for anti-immigrant sentiment.

Table 3: Participants Against Immigration

Participant	Economic Reasons	An Attack on American Culture	National Security
Donald Trump (R)			√
Susan Collins (R)			√
John Cornyn (R)			√
Ted Cruz (R)	√		√
Lindsey Graham (R)		√	√
Mitch McConnell (R)		√	√
Marco Rubio (R)		√	√
Kevin McCarthy (R)	√		

In continuation, I put all 8 participants that were against immigration into three categories. These categories consisted of reasons for the participants’ anti-immigrant sentiment; economic reasons expressed the belief that immigrants hurt the economy by taking American jobs, an attack on American culture expressed the belief that immigrants are a threat to white, English speaking culture, and national security expressed the fact that looser immigration laws will invite foreign threats into the United States (Durand, 2017). My results illustrated that all of these participants are Republicans and seven of them think that immigration poses the greatest threat to national security based on their comments. For instance, Trump stated, “They’re bringing crime and they’re rapists.” Additionally, three thought that immigration is an attack on American culture. For example, Lindsey Graham stated that “We have to change our laws so these people stop coming. There’s a narrative in Central America that if you can get to America with a minor child, you will never get deported, and we have to change that storyline.” Lastly, two stated that they do not agree with immigration due to economic reasons. For instance, McCarthy asserted, “We should ensure that illegal immigrants are not receiving any of the benefits that are reserved for American Citizens.” Table 4 shows these participants as well as their reasons for supporting immigration, using the reverse of Durand’s (2017) three reasons.

Table 4: Participants in support of immigration

Participant	Enhance Economy	Enhance American Culture	Enhance National Security
Barack Obama (D)			√
George W. Bush (R)	√	√	
Joe Biden (D)			√

STMU-MSRJ

Beto O'Rourke (D)	√		
Julian Castro (D)			√
Joaquin Castro (D)			√
Mitt Romney (R)		√	
Nancy Pelosi (D)	√		
Cory Booker (D)		√	
Susan Collins (R)		√	√
Kamala Harris (D)		√	
Amy Klobuchar (D)		√	
Charles Schumer (D)			√
Elizabeth Warren (D)		√	
Bernie Sanders (D)		√	
Alexandria Ocasio-Cortez (D)		√	
Ayanna Presley (D)	√	√	
Rashida Tlaib (D)		√	
Ilhan Omar (D)		√	
Christina Jimenez (D)		√	
Selena Gomez (D)		√	
Chrissy Teigen (D)		√	

John Legend (D)		√	
Nicki Minaj (D)		√	
Kim Kardashian West (D)		√	
Kanye West (R)		√	
Cardi B (D)		√	
Ellen Degeneres (D)		√	
Jim Carrey (D)		√	
Jimmy Kimmel (D)		√	
Chris Cuomo (D)			√
Gregg Popovich (D)		√	
Hillary Clinton (D)		√	

Additionally, 33 participants of both parties were in favor of immigration. However, there were only four Republicans that supported immigration, which were George W. Bush, Susan Collins, Mitt Romney, and Kanye West. Senator Susan Collins believes that DREAMers should be here legally. Susan Collins said, “provide a pathway to citizenship for the DREAMer population, those young people who were brought to America through no decision of their own.” Also, every member of the House of Representatives, activists, comedians, and influencers aligned with their particular party but Kanye West. Kanye cared about children who seek asylum in the United States, affirming, “I believe in love and compassion for people seeking asylum and parents who are fighting to protect their children from violence and war.”

Interestingly, the majority of the participants are in favor of immigration and think that immigration enhances American

culture. For instance, Kamala Harris said, “we are a country of immigrants. It’s time for America to lead with our values and enact comprehensive reform.” Also, only four participants that were in favor of immigration thought that immigration enhances the economy. For example, George W. Bush stated, “critical contributions immigrants make to our prosperity and our way of life.” Lastly, eight of the participants thought that immigration enhances national security. For instance, Joaquin Castro said, “the overwhelming majority of these folks are not people who come to America to do harm or commit crimes, these are people who are fundamentally seeking a better life.”

Additionally, 17 women were for immigration and 16 men were also for immigration based on their comments. On the other hand, one woman was against immigration and seven men were against immigration based on their comments. Most of the participants who are women thought that immigration enhances American culture, except for a few such as Nancy Pelosi, and Ayanna Presley. In fact, 16 of the participants who are women and 9 of the participants who are men thought that immigration enhances American culture. Only four participants stated that immigration contributes to the economy. Two of the participants are men and the other two are women. For example, Ayanna Presley said, “across the Massachusetts 7th Congressional District, more than 250,000 foreign born residents are contributing immensely to the economic, social and cultural vibrancy of our communities.” Interestingly, Presley actually supported immigration because of both themes, economic and cultural. In addition, seven of the participants thought that immigration enhances national security. Six participants were men and one was a woman. For instance, Julian Castro said, “when somebody comes across the border, not to criminalize desperation, but to treat that as a civil violation.”

Discussion

Republicans are less aligned with political party values. In other words, the Republican participants agree with some Republican party values, but not with everything Republicans

say. For example, Kanye West and Susan Collins are Republicans, the latter a lawmaker and the former an artist, and they do not agree with children being separated from their parents and children being mistreated by the American government. This is less likely for a Republican to say because Democrats tend to usually protect and defend immigrants (Diffen.com) Also, Republicans, like every politician, hunt for votes to win the election by getting the attention of voters from the opposing party. Republicans tend to care more about how they could get into office rather than their constituents.

Democrats are more likely to be aligned with their political party values. Every Democrat supports immigration to an extent. President Barack Obama supports immigration but does not support those who are foreign-born criminals in the United States. Obama said during a speech, "deportations of criminals are up 80%." I think Democrats tend to stand with immigration because they are part of a minority group, know someone who is a minority, or grew up in an environment surrounded by minorities. Democrats tend to care much about the diverse culture that is in America.

It is interesting that more women than men are in support of immigration. Also, most men who are against immigration are Republican males. However, that is common in today's American society (Kosoff, 2018). Women align more with Democrats than with Republicans because women believe that Democrats support women-based issues such as equal pay, equal work, and equal legal rights (ushistory.org). Durand (2017) says that there are three main reasons why Americans believe that immigrants are a threat to the United States. The reasons are economic reasons, an attack on white, protestant, English-speaking American culture, and national security. The results showed that Republicans think that immigration threatens America's national security. Many Republicans think that immigrants are terrorists or criminals (Franzblau, 1997). However, statistics have shown that most people who actually put our national security at risk are white people who are domestic terrorists and not immigrants. From

1975-2017, there were 788 native born-terrorists in comparison to 192 foreign-born terrorists (Nowrasteh, 2019). This goes to tell you that the people born in the United States are the criminals and terrorists.

Conclusion

Although Central Americans experience incredible suffering in the Northern Central American Triangle, their suffering continues in America as well. Americans see Central American immigrants as criminals, terrorists, a threat to American culture, and an economic threat in terms of immigrants taking American jobs.

This study presented a thematic analysis of American political figures', public figures', comedians', actors', activists', and influencers' discourse against or for immigration. Most of the participants, regardless of political affiliation, aligned with their party's political values. However, there was a little more than 25% that did not align with their political values. Essentially, not all Republicans align fully with all of their party values. Kanye West, Susan Collins, George W. Bush, and Mitt Romney were the only ones who had a different opinion on different matters regardless of political affiliation. Additionally, the majority of women tended to support immigration whereas approximately half of all the men did not support immigration.

Also, most figures who are against immigration think that national security is the biggest threat to America when it comes to immigration. Most figures who are for immigration tend to think that immigration enhances American culture.

Lastly, and most importantly, the study means to remind the audience that regardless of what happens there are many people with huge platforms on television and social media who support and fight for immigrants. As Selena Gomez once said, "As a Mexican-American woman, I feel a responsibility to use my platform to be a voice for people who are too afraid to speak". Everyone must do their part to protect, support, and voice their opinion when it comes to immigration. The political figures fight day in and day out about immigration related issues and public

figures express their opinions on social media such as Instagram and Facebook. It is essential to inform friends and family about the immigrant rhetoric in the United States.

References

Astorga Morales, A. 2017. “La región del Triángulo Norte Centroamericano y el círculo vicioso: violencia, pobreza y migración.” *Revista Conjeturas Sociológicas*, 5(12), 10-32.

ABC News. (2019, July 14) Sen. Amy Klobuchar ICE raids are ‘about scaring everyone in the country’ [Video] YouTube. https://www.youtube.com/watch?v=MbfBw_R-o1k

Booker, C. [@corybooker]. (2019, June 21). Our immigrant communities should not have to live in fear. No matter how much the Trump administration tries to strip your humanity, you have rights. [Tweet]. Twitter. <https://twitter.com/corybooker/status/1142206437155909632?lang=en>

Bruner, R. (2017, January 31). Trump Immigration Ban: Ellen DeGeneres on Finding Dory

VIDEO. Retrieved June 25, 2020, from <https://time.com/4654985/ellen-degeneres-immigration-ban/>

Cardi B, Bernie Sanders discuss immigration, police brutality. (n.d.). Retrieved June 25, 2020, from <https://abcnews.go.com/Politics/cardi-bernie-sanders-discuss-immigration-police-brutality-campaign/story?id=64992472>

CBS News. (2019, March 18). George W. Bush says immigration is a “blessing & a strength” [Video] YouTube. <https://www.youtube.com/watch?v=R0HpsyiMxCw>

Charles Schumer on Immigration. (n.d.). Retrieved June 25, 2020, from https://www.ontheissues.org/international/Charles_Schumer_Immigration.htm

CNN. (2014, November 20). Obama unveils new immigration plan [Video] YouTube. <https://.youtube.com/watch?v=z5oKIKeXWLQI2>

CNN. (2014, June 17). Hillary Clinton: Deportation makes no sense. [Video] YouTube. <https://.youtube.com/watch?v=xui6gdlfXBI>

Create a Fair & Welcoming Immigration System: Elizabeth Warren. (n.d.). Retrieved June 25, 2020, from <https://2020.elizabethwarren.com/toolkit/fair-and-welcoming-immigration>

Democrat vs Republican. (n.d.). Retrieved June 25, 2020, from https://www.diffen.com/difference/Democrat_vs_Republican

Dudley, S and Héctor Silva Ávalos 2019. “MS13 In the Americas: Major Findings.” InSight Crime. https://www.insightcrime.org/investigations/ms13_major_findings/ (April 15, 2020).

Durand, J. (2017). La inmigración como amenaza en Estados Unidos. Anuario CIDOB de la inmigración, 32-49.

Fox News. (2019, April 14) Lindsey Graham drafting legislation to fix immigration laws. [Video] YouTube. https://.youtube.com/watch?v=llFJKIG_e4Q&feature=youtu.be&t=87

Franzblau, K. J. (1997). Immigration's impact on US national security and foreign policy. Washington, DC: US Commission on Immigration Reform.

Good Morning America. (n.d.). Selena Gomez speaks up on immigration, sharing family's story. Retrieved June 25, 2020, from <https://www.goodmorningamerica.com/culture/story/selena-gomez-speaks-immigration-sharing-familys-story-65999270>

Gomez, S. [@selenagomez]. (2019, June 29). Kids in cages! Sleeping on concrete floors with aluminum blankets! No access to simple dignities! How is this happening??? [Photograph]. Instagram. https://.instagram.com/p/BzS_2doDAsG/?utm_source=ig_embed

Gomez, S. (2019, October 01). Selena Gomez on America's Undocumented Immigration Crisis. Retrieved June 25, 2020, from <https://time.com/5690070/selena-gomez-americas-immigration-crisis/>

How Bernie Sanders would change immigration. (n.d.). Retrieved June 25, 2020, from <https://www.politico.com/news/2019/11/07/bernie-sanders-2020-immigration-plan-067204>

Immigration & Border Security. (2020, February 28). Retrieved June 25, 2020, from <https://.cornyn.senate.gov/content/issues/immigration-border-security>

Immigration. (n.d.). (2017, January 19). Retrieved June 25, 2020, from <https://www.cruz.senate.gov/?p=issue&id=33>

Immigration. (n.d.). Retrieved June 25, 2020, from <https://kamalaharris.org/issue/immigration/>

Immigration. (n.d.). Retrieved June 25, 2020, from <https://kevinmccarthy.house.gov/issues/immigration>

Immigration. (n.d.). Retrieved June 25, 2020, from <https://omar.house.gov/issues/immigration>

JoaquinCastroTX. (2014, May 7). Rep. Joaquin Castro Discusses Need for Immigration Reform [Video] YouTube. <https://.youtube.com/watch?v=EDimziL0XQw>

Kosoff, M. (2018, July 23). Why Female Millennials' Views on Immigration Could Doom the G.O.P. Retrieved June 25, 2020, from <https://www.vanityfair.com/news/2018/07/how-millennial-women-views-on-immigration-could-doom-republicans-trump-2018-midterms>

Keller, Allen, Amy Joscelyne, Megan Granski, and Barry Rosenfeld. 2017. "Pre-Migration Trauma Exposure and Mental Health Functioning among Central American Migrants Arriving at the US Border." Plos One 12(1).

LaRock, D. (February, 2020). Interfaith Welcome Coalition. Presented to St. Mary's University, San Antonio, TX.

Legend, J. [@johnlegend]. (2017, September 5). Quit calling human beings "illegal aliens". They're people. They're our friends, neighbors and co-workers. They're dreams & lovers [Tweet]. Twitter. <https://twitter.com/johnlegend/status/905184750574362624?lang=en>

Marco Rubio on Immigration. (n.d.). Retrieved June 25, 2020, from https://house.ontheissues.org/International/Marco_Rubio_Immigration.htm

Margesson, R., Seelke, C. R., & Taft-Morales, M. (2016). Unaccompanied children from Central America: Foreign policy considerations. Congressional Research Service.

Marine, B. (2018, June 21). Why Did It Take Kim Kardashian So Long to Speak Up About Donald Trump's Immigration Policy? Retrieved June 25, 2020, from <https://www.wmagazine.com/story/kim-kardashian-trump-family-seperation/>

Matt Hildreth on March 25, 2., & Hildreth, M. (2019, May 11). Immigration 101: What is Zero Tolerance Family Separation? Retrieved June 25, 2020, from <https://americasvoice.org/blog/separation-of-children/>

McCluskey, M. (2018, June 15). Jimmy Kimmel Welcomes New U.S. Citizens to America. Retrieved June 25, 2020, from <https://time.com/5313396/jimmy-kimmel-welcomes-immigrants/>

McMillen, G. et al. (2017, January 30). Gregg Popovich rips into Donald Trump over immigration ban. Retrieved June 25, 2020, from <https://www.sportingnews.com/us/nba/news/gregg-popovich-rips-donald-trump-immigration-ban-san-antonio-spurs/113r5tp4gkv2f1te21j56oeiph>

“Migrant Protection Protocols.” 2020. Department of Homeland Security. <https://www.dhs.gov/news/2019/01/24/migrant-protection-protocols> (April 15, 2020).

Minaj, N. [@NICKIMINAJ]. (2019, February 4). Your obsession with our culture is scary to say the least. I hate giving you the attention you so desperately crave. [Tweet]. Twitter.<https://twitter.com/nickiminaj/status/1092497946526896129?lang=en>

Moran, L. (2019, August 28). Cuomo Blasts Trump On Immigration: Personal To Me, Should Be To You. Retrieved June 25, 2020, from https://www.huffpost.com/entry/chris-cuomo-donald-trump-immigration-2020_n_5d6621b8e4b01fcc690bc723

MSNBC. (2018, January 12). Donald Trump's Comments On Immigration: They're Rapists. They All Have AIDS| Velshi & Ruhle| MSNBC [Video] YouTube.
<https://.youtube.com/watch?v=dnCSM53gC70>

Mueller, Z. (2020, February 28). Immigration 101: What is 'Remain in Mexico', or the Migration Protection Protocols (MPP)? Retrieved from <https://americasvoice.org/blog/remain-in-mexico-mpp/>

NBC News. (2019, June 27). Julian Castro Was Big on Immigration Policy and went after O'Rourke at Dem Debate | NBC NEWS [Video] YouTube.
https://.youtube.com/watch?v=kJ51KsITM_E

NBC News. (2019, April 7). Full Romney Immigration is 'overwhelming our system' | Meet The Press | NBC News. [Video] YouTube. https://.youtube.com/watch?v=tfo_B9yNGnE

NowThis News. (2019, February 9). Why ICE Must Be Stopped, According to Rep Tlaib |NowThis. [Video] YouTube.
<https://.youtube.com/watch?v=KW55lkvK9fo>

Newsy. (2019, April 12). Mitch McConnell calls for immigration talks. [Video] YouTube.
<https://.youtube.com/watch?v=SnkbnVXo8pk>

O'Connor, A., Batalova, J., & Bolter, J. (2019, August 15). Central American immigrants in the United States. Migration Policy Institute. Retrieved from

<https://migrationpolicy.org/article/central-american-immigrants-united-states>

O'Rourke, B. [@BetoORourke]. (2020, April 22). If you stopped immigration, you'd stop America. Whether it's food production, job creation, economic growth, innovation or healthcare, immigrants are critical to our success. [Tweet]. Twitter. <https://twitter.com/betoorourke/status/1252957021881712642?lang=en>

PBS NewsHour. (2019, May 16). WATCH: House Speaker Pelosi may address immigration during news conference [Video] YouTube. <https://youtube.com/watch?v=cWlAnrDcSYA&t=831s>

Pierce, S. (2019). Immigration-related policy changes in the first two years of the Trump administration. Washington DC, Migration Policy Institute, available in: www.migrationpolicy.org/research/immigration-policy-changes-two-years-trumpadministration.

Rep. Pressley Calls on Local Leaders to Protect Immigrants. (2019, August 06). Retrieved June 25, 2020, from <https://pressley.house.gov/media/press-releases/rep-pressley-calls-local-leaders-protect-immigrants>

"Policies Affecting Asylum Seekers at the Border." 2020. American Immigration Council. <https://www.americanimmigrationcouncil.org/research/policies-affecting-asylum-seekers-border> (April 15, 2020).

Rodriguez, N., Urrutia-Rojas, X., & Denny, N. R. (1990). Undocumented and Unaccompanied: A Mental-health Study of Unaccompanied, Immigrant Children from Central America. Institute for Higher Education Law & Governance, University of Houston Law Center.

Senator Susan Collins. (n.d.). Retrieved June 25, 2020, from <https://collins.senate.gov/newsroom/icymi-senator-collins-discusses-immigration-russia-investigation-cbs%E2%80%99s-%E2%80%9Cface-nation%E2%80%9D>

Simon, A. (2018, July 13). Immigration Activist Cristina Jiménez on Life Under Trump. Retrieved June 25, 2020, from <https://time.com/5337365/immigration-donald-trump-cristina-jimenez/>

SkyNews. (2019, July 12). Ocasio-Cortez speaks out about migrant conditions at the US border. [Video] YouTube. https://youtube.com/watch?v=pCs70-ddO_w

Teigen, C. [@chrissyteigen]. (2018, February 12). It's called perpetual otherism or perpetual foreigner syndrome. No one is ashamed of the word immigrant but it's tiring being treated as foreigners all the time. [Tweet]. Twitter. <https://twitter.com/chrissyteigen/status/963232760868425728?lang=en>

Thomsen, J. (2018, May 28). Jim Carrey goes after Trump for policy separating immigrant parents, children at border. Retrieved June 25, 2020, from <https://thehill.com/blogs/in-the-know/in-the-know/389603-jim-carrey-goes-after-trump-policy-separating-immigrant-parents>

TIME (2019, August 1). Joe Biden And Julian Castro spar on Immigration | TIME [Video] YouTube. <https://youtube.com/watch?v=ODoU-fxQKGo>

Terrorists by Immigration Status and Nationality: A Risk Analysis, 1975–2017. (2019, May 08). Retrieved June 25, 2020, from <https://www.cato.org/publications/policy-analysis/terrorists-immigration-status-nationality-risk-analysis-1975-2017>

West, K. [@kanyewest]. (2018, October 30). I support those who risk their lives to serve and protect us and I support holding people who misuse their power accountable. [Tweet].
Twitter.<https://twitter.com/kanyewest/status/1057366623621955586>

What Factors Shape Political Attitudes? (n.d.). Retrieved June 25, 2020, from <https://www.ushistory.org/gov/4b.asp>

Views of parties' positions on issues, ideologies. (2020, May 30). Retrieved June 25, 2020, from <https://.people-press.org/2016/06/22/5-views-of-parties-positions-on-issues-ideologies/>

Activity Levels of Bottlenose Dolphins (*Tursiops truncatus*) Before and After a Single Swimmer

Andrew Magee

Mentor: Heather M. Hill, Ph.D.
St. Mary's University, San Antonio, TX

*While there have been numerous studies aimed at assessing dolphins' responses to humans in human-animal interactions, the results have been conflicting. The current study aims to assess the surface activity levels of a group of bottlenose dolphins (*Tursiops truncatus*) in human care living in a natural lagoon at the Roatán Institute for Marine Sciences, Anthony's Key Resort, Honduras. Instantaneous data collected on the activity levels were compiled and analyzed to compare the percentage of time the dolphins spent in any given activity level before and after a single researcher collected in-water non-invasive observational video data. The results indicated no significant difference between the two periods, with the majority of time spent in low to moderate energy surfacing behavior. These findings indicate that the presence of a researcher collecting in-water data did not influence the overall level of surface activity exhibited and observed for this group of dolphins. Keywords: activity level, bottlenose dolphins, captivity, safe zone, single swimmer, *Tursiops truncatus**

There are long standing questions about whether humans can influence the behavior of cetaceans. This question elicits much controversy because depending on what is measured and how it is measured, the answers are mixed. Research with cetaceans in their natural habitats suggests that anthropogenic effects are negatively impacting populations. For example, cetaceans have been observed increasing dive duration and decreasing surface interactions as tourist boats approach, possibly indicating stress (as reviewed by De Vere et al., 2018). Other research indicates that cetaceans, like dolphins, can create

cooperative relationships with humans such as in fisheries contexts (as reviewed by De Vere et al., 2018) and the lives of the cetaceans are enhanced. And still, other evidence suggests that many cetaceans seek interactions with humans, such as bow riding and investigations of swimmers and boats in the water (as reported by De Vere et al., 2018), suggesting cetaceans may sometimes be reinforced by these interactions.

One topic that needs additional research both in the wild and in controlled settings is the direct impact of humans on cetacean behavior. Many challenges exist for studying this topic due to the difficulties associated with data collection and access to animals found in both settings. In the wild, observations are considerably more challenging and less consistent than captivity. For example, access and visibility of animals, control of types of human effects, and identification of individuals are more difficult in the wild than in controlled settings. To address the influence of humans on the behavior of free-swimming cetaceans, knowledge of the baseline behavior when humans are absent is necessary to compare behavior when humans are present. This question can only be answered through non-invasive observation techniques, such as passive acoustic monitoring or observations of animals during encounters in which habituation has been achieved. Research that has examined this question has primarily focused on dolphin species. For example, Scarpaci and colleagues (2000) found an increase in whistling by dolphins as Swim With Dolphin (SWD) boats approached. Unfortunately, the explanation of the increased whistling was unclear. The change in behavior of the dolphins could have been due to the physical separation of the dolphins, added ambient noise from the boat and swimmers, excitement of the dolphins, or induced stress in the dolphins. In another study, Dudzinski and colleagues (2012) found that a single swimming researcher did not appear to influence the pectoral fin contact displayed by dolphins from several different field sites. Indo-Pacific dolphins (*Tursiops aduncus*) off of Mikura Island engaged in similar levels of pectoral fin contact as Atlantic spotted dolphins (*Stenella frontalis*) off of Bimini in The

Bahamas, which suggested that the behavior was conserved across different dolphin species, geographic locations, and potentially not influenced by the researcher. In both examples, the presence of humans was not controlled and could not be compared to a baseline in terms of human absence. This lack of control leads to issues with interpretation of the cause of the behavior of the studied animals. Controlled environments provide opportunities to explore the influence of humans on dolphin behavior more methodically (Dudzinski, 2010; Perelberg et al., 2010).

Unfortunately, there has been considerable backlash against dolphins in captivity and by extension, programs that allow humans to interact with dolphins (Kynngdon et al., 2003; Miller et al., 2018). Arguments against dolphins in captivity suggest that the controlled environment suppresses the behavioral repertoire, which would lead to under stimulation and boredom, and that interactions with humans are stressful and not voluntary. Arguments for dolphins in captivity suggest that dolphin interactions with humans are reinforcing. Moreover, when grouped in appropriate social groupings, managed care can elicit the full expression of their behavioral repertoire, except in cases in which foraging is not present. To begin to address this controversy, research that focuses on specific dolphin responses to humans in their environment under controlled and less controlled situations is needed.

Dolphin Activity Without Humans

Dolphins of all species have a sophisticated social hierarchy and much of their behavior is play-related or socializing with others, presumably to maintain the social structure. Dolphins (*Tursiops* spp.) in captive settings engage frequently in low intensity play during the day and low intensity swimming at night (Walker et al., 2017). At the earliest stages of development, mother dolphins actively rear their calves through varying swim patterns, disciplinary actions, and different types of maternal care and bonding activities (Hill et al., 2007; Hill et al., 2008). These

activities require higher activity levels at earlier ages, but then slow down as calves develop and dolphins mature. It seems likely in both developing calves and adults, that low activity levels likely allow the dolphins to conserve energy for future activities requiring more effort (Walker et al., 2017). Dolphins are also observed to engage in synchronous and slow close-proximity swimming when not engaging in more active behaviors, such as foraging, socializing, or playing. During social interactions, dolphins engage in various tactile exchanges with others, which appear to create, strengthen, or maintain a bond or relationship (Dudzinski et al., 2012). Captive dolphins engage in play activity significantly more than wild dolphins, likely due to the lowered arousal and greater amount of time available with food provisioning. Play in captive dolphins may be different from wild dolphins due to chances to engage in human-influenced opportunities, such as the types of objects provided by humans versus naturally occurring objects (Greene et al., 2011). Although juvenile dolphins engaged in significantly more play, dolphins of all ages have been observed to engage in solo play and play with others (Cappiello et al., 2018; Kuczaj et al., 2006). Depending on what form it may take, solo play could indicate higher activity levels during times when no training or human interaction is present.

Clearly, varying levels of activity are expected of dolphins whether in controlled environments or in their natural habitat and certain parameters may be guiding the display of different levels of activity. This baseline knowledge is needed to be able to interpret any changes in behavior that might be related to the presence of humans (Clegg et al., 2017). Captive dolphins are particularly valuable because they are generally comparable to wild dolphins, while remaining more accessible and providing more consistent data collection opportunities (Dudzinski, 2010; Perelberg et al., 2010).

Dolphin Activity in the Presence of Humans

Little research has gone towards assessing the simple activity level of the dolphins as affected by humans. Recent evidence indicates that dolphins in controlled environments change their behaviors and overall activity levels when humans are present (Jensen et al., 2013). Another context in which behaviors of dolphins, as influenced by humans, is assessed include programs in which humans swim with the dolphins. There are many “Swim With Dolphins” programs (SWD) around the world in which humans enter the water to interact with the dolphins more closely and in their aquatic environment. Research investigating the impact of humans on dolphin behavior during SWD programs has become more frequent, but with limited agreement in conclusions (Bresning et al., 2005; Kyngdon et al., 2007; Trone et al., 2005).

As described earlier, a commercial SWD program with wild dolphins resulted in higher acoustic activities by the dolphins, which may have indicated a desire of the dolphins to remain in contact with each other, but could have simply been an expression of excitement (Scarpaci et al., 2000). A study conducted with a captive group of dolphins found similar evidence for excitement of the dolphins following a SWD program (Trone et al., 2005). Although dolphin behavior was not significantly different, short term or long term, in relationship to the SWD program, play behavior both with objects and humans immediately after the program was more frequent, indicating a positive response by the dolphins to the human-dolphin interactions (Trone et al., 2005).

In contrast, a study at a different facility resulted in a very different conclusion after dolphins retreated to an area of the pool in which humans were not present during an SWD program (Kyngdon et al., 2007). The researchers interpreted the dolphin retreat behavior as a behavioral manifestation of needing more space from humans (Kyngdon et al., 2007). This interpretation was supported by an earlier study in which dolphins were attracted to adult swimmers when sufficient space was available

but showed signs of stress when adult swimmers were present in an environment with limited space (Bresning et al., 2005).

The Current Study

Although there have been numerous studies involving dolphin interactions with humans, there have been no studies regarding dolphin activity level in the presence of a human not interacting with dolphins. Additionally, most if not all available studies surround dolphins' interactions with multiple humans rather than a single human. These are significant shortcomings of the previous studies. With some knowledge of the effect a single human has on captive dolphins' activity levels, any problems created by dolphin-human interactions could be more specifically assessed. The current quasi-experimental study aims to discover the effect the presence of one human on the activity levels of the dolphins at an international facility with a natural lagoon and large social grouping that interacts with familiar and unfamiliar humans regularly. In this study, we examined the influence of the presence of a researcher who did not interact with the dolphins while swimming to collect underwater audio-visual data on the activity level of the dolphins. As part of swim with dolphin program guidelines, a safe zone, or sanctuary area in which humans should not enter and is directly available to the animals (Animal and Plant Health Inspection Service, 2016), is present. The current study assessed the activity levels of dolphins present in either the main lagoon or the safe zone before and after the swimming researcher was in the water to determine if the dolphin behavior was altered.

Method

Subjects

Depending on the data collection year, 18 to 20 bottlenose dolphins (*Tursiops truncatus*) were the subjects of the current study. The dolphins were housed at the Roatan Institute for Marine Sciences (RIMS) in Roatán, Honduras. Ranging in age from newborn to 30 plus years old, the majority were born into managed care with the older animals being born in the wild. Sex

was evenly distributed. The dolphins live in a lagoon enclosure with depths ranging from the shore to eight meters. The enclosure is approximately three football fields in surface area. In the enclosure, there is an identified safe zone from which humans are discouraged to enter while free-swimming so that the dolphins are free to enter without a human presence.

Sample

An archived set of data collected by groups sponsored by the Dolphin Communication Project on the RIMS dolphins over a period of a year and three months were used for the present study. Data consisted of 18 days from January 2019, 2 days from December 2019, 12 days from January 2020, and 1 day from March 2020, for a total of 33 days. Approximately 23 hours and 55 minutes of observations were recorded. Data were derived from two sets of observations surrounding a research data collection session: (1) collected immediately before a single swimming researcher entered the water and (2) immediately after the single swimming researcher left the water. Data collected during the research session were excluded. Approximately twice as much data were available for the lagoon than the safe zone due to a data collection procedural change from January 2019 to December 2019 and remaining dates.

Measures

The dolphins' activity levels (AL) were the primary dependent variables for the current study. Five levels of activity were assessed: "not visible" (NV), activity level 1 (AL_1) indicating the subjects were mostly inactive, floating on the surface, or slowly swimming, activity level 2 (AL_2) indicating the subjects were engaging in slow to moderate swimming, possibly swimming in pairs or up to four dolphins swimming together without splashing on the surface, activity level 3 (AL_3) indicating the subjects were engaging in moderate swimming and changing directions, investigating the environment, likely engaging in some tactile interaction with peers, activity level 4

(AL_4) indicating the subjects were more actively swimming, surfing and splashing at the surface, producing audible vocalizations, engaging with humans if humans were present, interacting with objects and each other, possibly slapping at the surface, or activity level 5 (AL_5), indicating the subjects were swimming actively, leaping, producing loud vocalizations, socially active, or engaging in aerial activity.

Procedure

Data Collection

The majority of the observations were collected beginning around 7:30 am, with other observations at different times of the day (e.g., 6:20 am to 6:50 pm). One human swimmer would enter the enclosure to collect video recordings of the dolphins for approximately 15-25 minutes. Trained students, professors, and other researchers recorded the corresponding dolphin activities onto paper ethograms for five-minute observation blocks, using 1-minute instantaneous sampling. That is, activity levels were assessed every minute for visible surface social groupings. When multiple data collection groups were available, the enclosure was divided into as many sections as there were groups to facilitate independent observations (e.g., one data collection group observed the whole enclosure, three data collection groups split the enclosure into three equal areas). Observer groups were stationed at different vantage points around the enclosure to enable independent observations. For this data set, a total of 17 unique observer locations were present for data collection. Observers would begin recording 5-10 minutes before the swimming researcher entered the water, 15-25 minutes while the swimming researcher was in the water, and 5-10 minutes after the swimming researcher was out of the water. One minute instantaneous sampling was performed for a total of five minutes per block with a three-minute break between each observation block. Observations were split between two designated enclosure areas: safe zone and lagoon. The overall activity level of multiple groups of visible dolphins was ascertained as quickly as possible

for each designated enclosure area. Sometimes, multiple groups of dolphins had different activity levels within the same area. To address this variation, the larger group's activity was recorded as primary activity level for that location and the smaller group's activity was recorded as secondary activity level for that location. This protocol was utilized for data collected beginning December 2019. Data collected January 2019 only recorded an overall activity level for all visible dolphins across the enclosure for each interval.

Data Processing

All ALs per minute were collapsed and converted into percentages to represent an estimated percentage of time dolphins were observed in specific ALs for different areas. Thus, for each AL, the number of intervals in which that activity level was observed was divided by the total number of intervals for that 5-minute observation block (i.e., 5 intervals) and multiplied by 100. For example, a 5-minute observation block had three intervals at AL1 and two intervals at AL2. Activity level 1 would be converted to 60% ($3/5 * 100$), and AL2 would be converted to 40%. In some cases, there were intervals of less than five. In these cases, percentages were calculated in the same way, but using the number of intervals collected for that observation (i.e., 3 or 4). As the classification of primary or secondary activity level is not relevant to this study, the primary and secondary activity levels were averaged for the lagoon and for the safe zone into a single percentage for each interval of each location. For consistency purposes, all missing data were converted to zeros before collapsing.

Results

Two mixed model 2 (session type) x 5 (activity level) ANOVAs were conducted to assess the effects of session type on the percentage of time in activity level (AL) for the lagoon area and for the safe zone area. There were no significant interactions between the ALs and session type for either the lagoon (Figure

1a) or the safe zone (Figure 1b). There were also no significant main effects for the percentage of time spent in each AL before versus after the swimming researcher for either the lagoon or the safe zone areas. There were, however, significant main effects between the percentage of time spent in different ALs for the lagoon, Huynh-Feldt, $F(1.71, 556.78) = 126.18, p < .001, \eta^2 = .35$, and the safe zone, Huynh-Feldt, $F(2.42, 556.78) = 30.13, p < .001, \eta^2 = .12$.

Paired sample t-tests were conducted for post hoc analyses using a Bonferroni correction ($p < .005$) for each significant main effect of AL. For both the lagoon and the safe zone, ALs 1 and 2 were significantly different from all other ALs (i.e., 3, 4, and 5), but activity ALs 1 and 2 were not different from each other in either area (Table 1). The exception to the post hoc analyses was in the safe zone, where AL 1 was not different from AL 3. The greatest percentage of time was spent in AL 2, followed by ALs 1, 3, 4, and 5, respectively (Figure 1 and Table 2). Time in which animals were not visible was also examined, and there was no significant difference in the percentage of time between the lagoon (15%) and the safe zone (19%).

Table 1

Paired Sample T-tests Post Hoc Analyses for Activity Levels per Enclosure Area

	Lagoon			Safe Zone		
	M percent	df	p	M percent	df	p
AL_1_AV - AL_2_AV	1.48	231	.142	-2.36	231	.019
AL_1_AV - AL_3_AV	10.00	231	< .001*	2.78	231	.006
AL_1_AV - AL_4_AV	16.73	231	< .001*	4.60	231	< .001*
AL_1_AV - AL_5_AV	18.58	231	< .001*	5.82	231	< .001*
AL_2_AV - AL_3_AV	9.75	231	< .001*	6.18	231	< .001*
AL_2_AV - AL_4_AV	13.49	231	< .001*	7.80	231	< .001*
AL_2_AV - AL_5_AV	14.42	231	< .001*	8.47	231	< .001*
AL_3_AV - AL_4_AV	7.88	231	< .001*	3.45	231	.001*
AL_3_AV - AL_5_AV	8.88	231	< .001*	4.72	231	< .001*
AL_4_AV - AL_5_AV	4.63	231	< .001*	3.22	231	.001*

Note. * indicated significant differences using Bonferroni correction of $p = .005$.

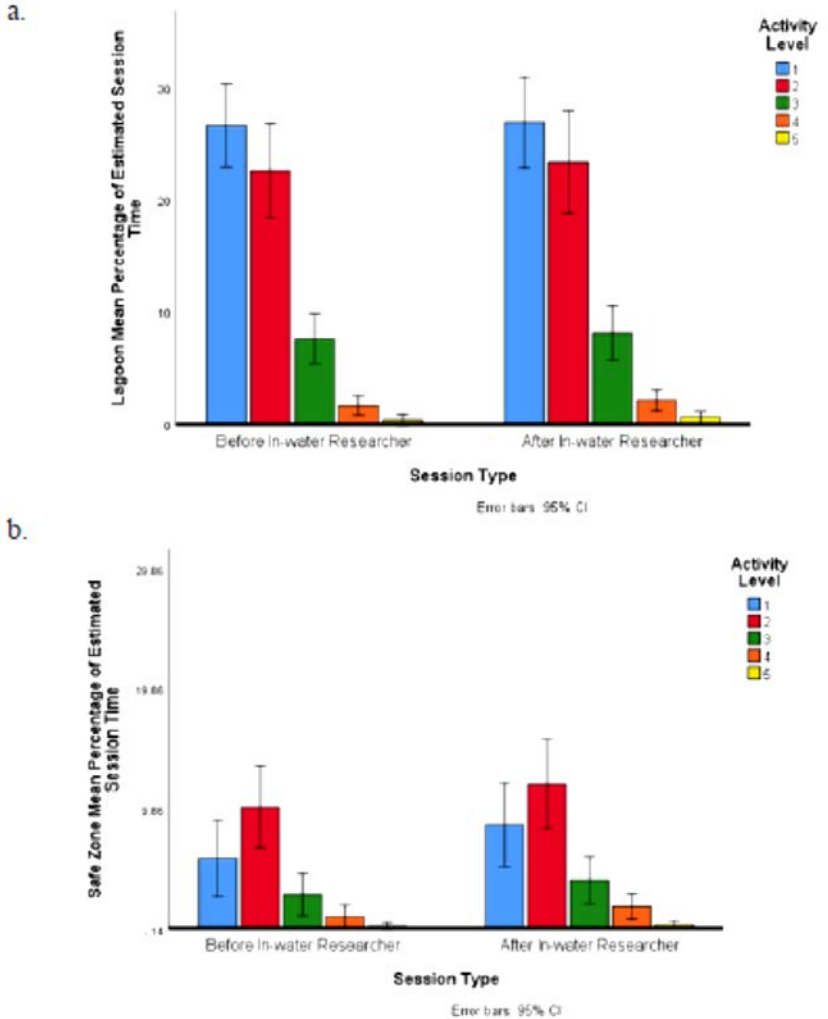
Table 2

Descriptive Statistics (n = 232) for each Activity Levels per Enclosure Area

Activity Level	Lagoon		Safe Zone	
	<i>M</i> percent	<i>SD</i>	<i>M</i> percent	<i>SD</i>
1	26.83	21.10	7.07	18.12
2	22.99	24.02	10.95	19.23
3	7.83	12.63	3.32	10.18
4	1.81	4.94	1.34	5.46
5	0.43	2.76	0.22	1.73

Figure 1

Activity Levels per Session Type per Enclosure Area



Note. Panel a is illustrating the lack of an interaction between the session type and activity level for the lagoon portion of the enclosure. Panel b is illustrating the lack of an interaction between session type and activity level for the safe zone portion of the enclosure. The overall activity level was significant for both enclosure areas.

Discussion

Previous research illustrated inconsistent findings regarding the impact of human swimmers on dolphin behavior, regardless of wild or captive setting (Bresning et al., 2005; Kyngdon et al., 2003; Scarpaci et al., 2000; Trone et al., 2005). The current study was unique from earlier studies because it was conducted in a large natural lagoon with an identified safe zone and a single swimming researcher who did not interact with the dolphins. Although the activity levels in both areas investigated (i.e., lagoon and safe zone) were expected to be higher after the swimming researcher left the water, the results indicated almost no difference between before and after the swimming researcher was in the water. These results suggest that the presence of a single swimming researcher did not influence the dolphins' behavior, which implies a benign impact on the dolphins' wellbeing.

Activity levels were expected to be higher in the lagoon than in the safe zone because the safe zone is considered an area of no human interaction and is therefore less arousing. This prediction was not supported fully as the dolphins displayed slightly higher levels of activity in the safe zone (AL 2 - slow swim, little wave action, vocally relatively quiet, pairs and small groups) versus the lagoon (AL 1 - resting, lack of awareness, quiet). Based on surface level activity, these findings suggest that the general degree of activity appears to be low and relaxed, which may have been related to energy conservation (Clegg et al., 2017) or time of day (Walker et al., 2017). Although there were higher levels of activity observed, these levels (i.e., 4 and 5) were not the norm in this context. Research on the 24-hr general activity budget for one captive population of bottlenose dolphins suggested that activity level was correlated with time of day (Walker et al., 2017), and perhaps these dolphins were still in a relaxed state prior to the training day. Additionally, the results of the current study were consistent with the results of a similar study involving groups of interactive swimmers in which activity level was observed to change very little during the dolphin swim

program (Trone et al., 2005). It is possible that the low level of activity while a single swimming researcher was present may have been facilitated by both the presence of one human and a large enclosure, and thus, the dolphins were likely not stressed (Bresning et al., 2005; Kyngdon et al., 2003).

Limitations and Future Directions

Surprisingly, the majority of the data collected indicated that the dolphins were in relaxed, slow-moving, non-vigilant states. It is possible that this outcome may have been related to the fact that most of the data were collected at the beginning of the dolphins' day, prior to the trainers arrival, and thus were not fully active or alert. Additionally, two procedures utilized for the study may have influenced the data somewhat: (1) data were collected for the safe zone and lagoon separately following the first set of data collected in January 2019, which did not differentiate between the two areas and (2) instantaneous sampling was conducted, which underrepresents the frequency of activity levels that were brief and not captured consistently. However, these procedural issues may be of limited concern. First, the data that were available for the safe zone appeared to be representative of the activities occurring in the safe zone when observed. Second, the minimal number of higher activity levels during observations was consistent for all data collection. Finally, some of the data utilized were collected by observers who were trained but became more proficient with experience across their week of observations. However, the impact of this experience on the resulting patterns should have been minimized by multiple observations and averaged data.

The findings of the current study support the assertion that dolphins in a controlled environment appear to be relaxed on average as indicated by low levels of activity and resting prior to the presence of a swimming researcher. Moreover, the presence of a single swimming researcher who does not interact with the dolphins appears to have little effect on the dolphins overall activity levels. This limited quasi-experimental study provides

some evidence that a large, social group of bottlenose dolphins housed in a natural lagoon within managed care is supported in terms of their wellbeing.

Future research should include the activity levels of the dolphins during the swimming researcher's time in the water. By comparing before, during, and after, a better understanding of the influence of one human who does not interact with the dolphins could be gained. The low activity levels in the current study likely imply that this group of dolphins is comfortable with this setting and likely have little stress due to humans. It is possible that if contextual information surrounding the higher energy behaviors or if data were collected more continuously, we could assess the presence of voluntary play with humans or affiliative social interactions between dolphins which have been shown to correlate with pleasure (Greene et al., 2011; Kuczaj et al., 2006). By examining the context and higher level of activity more specifically, we may be able to evaluate the influence of the number and types of swimmers (interactive guests vs interactive trainers) on dolphin behavior.

These types of studies are best performed in human care due to available animals that are consistently visible and recognizable as compared to field research. Moreover, these studies are more easily controlled than studies examining swim with wild dolphin programs as the animals' presence is more unpredictable. Before conclusions can be drawn about the welfare and presence of animals in human care, more experiments such as the current study are necessary.

References

- Animal and Plant Health Inspection Service. (2016). *2016 Animal Welfare Marine Mammals Docket*.
https://www.aphis.usda.gov/publications/animal_welfare/2016/docket_marine_mammals.pdf
- Brensing, K., Linke, K., Busch, M., Matthes, I., & Van Der Woude, S. E. (2005). Impact of different groups of swimmers on dolphins in swim-with-the-dolphin programs in two settings, *Anthrozoös*, *18*(4), 409-429.
- Cappiello, B. M., Hill, H. M., & Bolton, T. T. (2018). Solitary, observer, parallel, and social object play in the bottlenose dolphin (*Tursiops truncatus*). *Behavioural Processes*, *157*, 453-458. <https://doi.org/10.1016/j.beproc.2018.07.001>
- Clegg, I. L. K. Rödel, H. G., Cellier, M., Vink, D., Michaud, I., Mercera, B., Böye, M., Hausberger, M., Lemasson, A., & Delfour, F., (2017). Schedule of human-controlled periods structures bottlenose dolphin (*Tursiops truncatus*) behavior in their free-time. *Journal of Comparative Psychology*, *131*, 3, 214 –224.
<http://dx.doi.org/10.1037/com0000059>
- Deconto, L. S., & Monterio-Filho, E. L. A. (2016). Day and night sounds of the Guiana dolphin, *Sotalia guianensis* (Cetacea: Delphinidae) in southeastern Brazil, *Acta Ethologica*, *19*, 61–68. <http://dx.doi.org/10.1007/s10211-015-0223>
- Dudzinski, K. M. (2010), Overlap between information gained from complementary and comparative studies of captive and wild dolphins, *International Journal of Comparative Psychology*, *23*(4), 566-586.
- Dudzinski, K. M., Gregg, J., Melillo-Sweeting, K., Seay, B., Levingood, A., & Kuczaj, S. A. (2012). Tactile contact exchanges between dolphins: self-rubbing versus inter-individual contact in three species from three geographies. *International Journal of Comparative Psychology*, *25*, 21-43.

- Greene, W. E., Melillo-Sweeting, K., & Dudzinski, K. (2011). Comparing object play in captive and wild dolphins, *International Journal of Comparative Psychology*, *24*, 292-306.
- Hill, H. M., Greer, T., Solangi, M., Kuczaj, S. A. (2007). All mothers are not the same: maternal styles in bottlenose dolphins (*Tursiops truncatus*). *International Journal of Comparative Psychology*, *20*, 34-53.
- Hill, H. M., Carder, D. A., & Ridgway, S. H. (2008). Vigilance in female bottlenose dolphins (*Tursiops* sp.) before and after calving. *International Journal of Comparative Psychology*, *21*(1), 35-57.
- Jensen, A. L. M., Delfour, F., & Carter, T. (2013). Anticipatory behavior in captive bottlenose dolphins (*Tursiops truncatus*): a preliminary study. *Zoo Biology*, *32*(4), 436-444.
- Kuczaj, S. A., Makecha, R., Trone, M., Paulos, R. D., & Ramos, A. J. (2006). Role of peers in cultural innovation and cultural transmission: evidence from the play of dolphin calves. *International Journal of Comparative Psychology*, *19*, 223-240.
- Kyngdon, D. J., Minot, E. O., & Stafford, K. J. (2003). Behavioural responses of captive common dolphins (*Delphinus delphis*) to a 'Swim-with-Dolphin' programme. *Applied Animal Behaviour Science*, *81*, 163-170.
- Perelberg, A., Veit, F., van der Woude, S. E., Donio, S., & Shashar, N. (2010). Studying dolphin behavior in a semi-natural marine enclosure: Couldn't we do it all in the wild? *International Journal of Comparative Psychology*, *23*, 625-643.
- Miller, D. S., Anthony, R., & Golab, G. (2018). Assessing aquatic mammal welfare while assessing differing values and imperfect tradeoffs. *Aquatic Mammals*, *44*(2), 116-141.
- Scarpaci, C., Bigger, S. W., Corkeron, P. J., & Nugegoda, D. (2000). Bottlenose dolphins (*Tursiops truncatus*) increase

whistling in the presence of "swim-with-dolphin" tour operations. *Journal of Cetacean Research and Management*, 2(3), 183-185.

Trone, M., Kuczaj, S., A., & Solangi, M. (2005). Does participation in dolphin-human interaction programs affect bottlenose dolphin behavior? *Applied Animal Behaviour Science* 93(3-4), 363-374.

<https://doi.org/10.1016/j.applanim.2005.01.003>

Walker, R. T., Miller, L. J., Kuczaj, S. A., & Solangi, M. (2017). Seasonal, diel, and age differences in activity budgets of bottlenose dolphins (*Tursiops truncatus*) under professional care. *Journal of Comparative Psychology*, 30. <http://escholarship.org/uc/item/3qc0z4dq>

Colonias: A study of infrastructure disparities in South Texas counties and their effects on education levels

Angela Perez

Mentor: Larry Hufford, Ph.D.
St. Mary's University, San Antonio, TX

Along the U.S. Mexico Border of Texas, there is a variety of socio-economic communities that are home to a diverse population. In the Rio Grande Valley, this population is predominately Hispanic with strong roots on both sides of the Rio Grande River. In efforts to further develop the region, the State of Texas began to categorize low socio-economic communities defining them as colonias. According to the Texas Attorney General's website, a colonia is defined as, "A substandard housing development, often found along the Texas-Mexico border where residents lack basics services such as drinking water, sewage treatment, and paved roads." These services are everyday necessities that impact all other aspects of a resident's life, from their health to their future education. The purpose of this study is to identify the disparities in necessary infrastructure across communities classified as colonias and to demonstrate the effects these disparities have on the level of education colonia residents reach. The Rio Grande Valley is one of the fastest growing regions in the United States. In order for further development to occur, the region must change its response to low socio-economic communities and the challenges these residents face. Historically, Texas has initiated legislation to combat the poor living conditions of colonias, however, no program has been successful in tackling the root of the problem in an effective manner. It is important to study the development of colonias and educational accomplishments of their residents because it is the starting point of bettering the region as a whole. In this study, rather than focusing on a specific piece of legislation I will look at the demographics of the region by school districts in attempt to

find a correlation between the number of colonias in the region and education levels reached by residents.

Introduction

For decades, colonias have been a concern in the Rio Grande Valley, yet they are continuously written out of city plans further isolating these communities. The disparities that exist across the region in infrastructure have created a gap that has come to involve public health, education, and employment. It has become a task of the community members to become educated, find new ways of employment and healthcare on their own. This neoliberal subjectivity has allowed for colonias to survive with little to no help from the local and state government. However, if there is to be substantive community development in these areas, various levels of government must act.

The purpose of this study is to identify disparities in necessary infrastructure across low- income communities classified as colonias and to demonstrate the effects these disparities have on the level of education colonia residents attain. It clear that living conditions affect every aspect of life and can be a determining factor in the success of inhabitants. The two major questions of focus for this study are: Does living in a low-socio economic community defined as a colonia affect the education of residents? And, how does improving the infrastructure in these areas lead to more viable and sustainable communities overall? These questions will guide the research on the education track while also taking into consideration the perspective of infrastructure, the economy and other necessary factors. Three Texas counties bordering Mexico will be analyzed: Hidalgo, Cameron, and Starr counties. By utilizing the Texas Attorney General's Colonias Database and Texas Education Agency data, I will test the hypothesis that there is a correlation between school district performance and the number of colonias within that district. It is important to study colonias because they embody a group people that has been purposely forgotten for decades. The results of this study will not reflect the success of a

specific piece of legislation like precedent studies but reflect the success or failure of education in the three counties in the Rio Grande Valley and demonstrate the true disparities that exist across the region.

Literature Review

The literature over colonias is extensive. It covers relationships, infrastructure, legislative impacts, education, and investing in colonias. However, there is little literature on the long-term impact of living in a colonia nor is there established literature on how to better these communities. Multiple sources identify Mexican Americans as the majority of the population residing in colonias. It is also identified that, “Mexican Americans in the Rio Grande Valley have been denied equal access to opportunity for several generations through discrimination and segregation in schools, neighborhoods, places of employment, and courts,” (CPPP 2017:5). The literature collected dates back to 1976. This means that colonias have been a subject of interest for over four decades, yet the same problems identified then are identified in more recent studies. These problems include poverty in the form of low income, poor health, poor education and isolation in terms of infrastructure (Estes 1976: 9). With this in mind, one must continue to analyze the other sources to find common themes including infrastructure and education.

In analyzing Wendy Jepson’s “‘If no gasoline, no water’: privatizing drinking water quality in South Texas colonias,” a relationship between colonia residents and their surrounding environment developed due to the lack of proper infrastructure despite the increase in investment. This paradox has become the norm across the Rio Grande Valley and has created a reliance on water vending machines also known as *molinitos* for colonia residents to access clean water. The reasoning behind this reliance is because colonias have been written out of city planning, thus are not connected to clean water provided by the city. Rather, providing clean water became a private industry that

is not only unreliable, but has even been linked to causing health problems. Colonia residents normally drive to a *molinito* where they must pay for potable water. Furthermore, regarding the disparities, Danielle Rivera put forth an analysis of the Colonias Health, Infrastructure and Platting Status or CHIPS data set collected by the U.S. Geographical Survey in 2007. She discusses the inconsistencies in government data when it comes to colonias and the failure to look at built in environmental issues (Rivera 2014:124-128). These inconsistencies display a positive outlook of the governments impact in colonias, when in reality the number of residents is much higher and the environmental issues at hand are much greater.

Much of the literature focuses on the origin of colonias and how they came about. Colonias data, dates back to the Bracero Program of the early 1940's (Rivera 2014:120). This program brought Mexicans to the United States to fill jobs in the fields due to a shortage of labor because of World War II. Many of them decided to stay in the U.S. and became residents or citizens. Rivera states, "As these workers migrated to cities across Southern Texas, they encountered a severe shortage of affordable housing." Mexican Americans became a vulnerable population that feared legal repercussions from landowners if anything were to go astray. While most colonia residents were sold their land legally, due to their low-income status they went through informal financing systems such as paying in cash (Ward 2011:2). This gave the sellers leverage over colonia residents. Generally, residents delayed building a house until they received an official copy of the deed. In the study investigated in "El Titulo en la Mano", the residents stated, "the title is everything because without it you have nothing." The deed to their land meant everything to them. It gave residents stability, ownership, and allowed for them to fully participate in the local economy (Ward 2011:5). It is common in colonias for residents to build their homes in sections or not build at all until the plot is fully paid off (Olmedo 2016:182-183). This gave way to colonia developers taking advantage of residents and provided little to no

protection to the buyers when issuing contracts. Peter Ward and Carlos Olmedo categorize this as informal housing development when looking at the colonias that were meant to be developed under the Model Subdivision Rules that were enacted in 1989 (Olmedo 2016:183). Due to the postponement of building homes, these colonias attracted the attention of government officials. It led to the establishment of assistance programs that provided better protections for the buyer and added conditions to the seller (Olmedo 2016:183). Other legislative initiatives that have been attempted are identified in the literature. In Uribe's "Policy Driven Water Sector and Energy Dependencies in Texas Border Colonias," we see the analysis of Texas legislation passed in 1995. This legislation created a pathway for residents of colonias and by definition "urban slums" to obtain water, wastewater systems and eventually electricity in their homes. They believe there was a chain of command that could help increase access to basic infrastructure and increase the overall efficiency of the law (Uribe 2019: 9). This piece of legislation had limited results. It created a pathway to attaining basic infrastructure, but generated obstacles for those who were unable to accommodate their homes to the original requirements yet needed the last. Another piece of legislation highlighted across the literature is Texas Senate Bill 827. This bill classifies colonias into three categories: red, yellow, and green based on the risk to public health (Texas Secretary of State 2014:13). Red means that there is a lack of access to potable water, roads are unlikely to be paved, there is no access to sewage systems, and they are likely susceptible to flooding. Yellow categorizes colonias in better situations including existing potable water service, with approved wastewater disposal system. However, yellow colonias still lack adequate road paving, drainage and solid waste disposal. Green colonias have access to all the services mentioned above and thus pose the lowest level of risk to human health. This system of classification has helped the government target specific areas of greater need and allows them to identify and keep track of the progress made.

As we look further into the literature, the importance of education both in and out of the classroom resonates. Irma Ramos focuses on the importance of *promotoras* who have been a long-standing presence in colonias. They are residents of colonias who have undergone training generally in healthcare in order to educate their own communities. As described by Ramos, “Promotoras are the bridge between the people and the federal and state bureaucracies,” (Ramos 2001: 568). The goal is to inform the community on important topics such as environmental health, occupational safety and other health risks posed to colonia residents. Marlynn May writing in “Embracing the Local,” describes the, “Cameron Park Project” which was launched to provide environmental health education to colonia residents. However, the project ran into challenges due to problems identified in previous research that is isolation, poor education and lack of awareness. Without direct community connection, the project saw little to no success.

Inside the classroom, Texas has continuously failed to prepare all students for success (CPPP 2018). According to an evaluation done by the Center for Public Policy Priorities, “Texas’ Black and Hispanic students are less likely to graduate from high school on time than their white and Asian peers.” The gap in education reflects the gap in economic stability. In another publication by CPPP titled, “State of Texas Children 2017,” the authors highlight unique barriers for children raised in colonias, “Children growing up in the colonias face barriers in housing, education, and health, which can lead to slowed growth and low educational development rates.” This article depicts the structure of life in the Rio Grande Valley from the demographic makeup, the impact of ethnicity and race, living conditions and poverty, health, and the overall impact this has on the education of children in the Rio Grande Valley. The article also highlights the fact that most school funding comes from local property taxes, meaning that school districts who serve low- income communities have less financial backing to provide tools and resources for their teachers and students (CPPP 2017:11). The importance of

investing in the education of colonia residents in the Rio Grande Valley are echoed across multiple sources. From the Federal Reserve Bank of Dallas, a publication outlines the digital divide that exists across Texas. It has become almost impossible to be an active student without access to the internet to complete homework assignments and projects from home (Federal Reserve Bank of Dallas 2016: 12). Projects involving the Pharr-San Juan-Alamo Independent School District were also highlighted to demonstrate the district's effort in ensuring that their students had access to the internet and the technology needed to compete in academia. In an overview of the South Texas Region, the Greater Texas Foundation pinpointed that the Rio Grande Valley looks like the future of both Texas and the U.S. The area is a prime environment to develop and begin initiatives (Greater Texas Foundation 2011: 11). It also demonstrated how school districts have partnered with post- secondary institutions to create a pipeline for their students to achieve higher education. This pipeline is essential to the residents of colonias and other areas of the Rio Grande Valley due to the shift in the employment market. The demand for a post-secondary degree to gain employment in the Rio Grande Valley has dramatically increase in recent years. In his article, Salvador Contreras states, "the future of Texas depends in part in its ability to educate and train its young." He focuses on vicenarians¹ in Texas and the rate at which they earn different salaries post-grad depending on their region of residence. The McAllen-Edinburg- Mission area in the Rio Grande Valley ranked at the bottom in earnings. Contreras attributed this to the labor market available in the what is one of the poorest regions in the state of Texas (Contreras 2020: 3). Bottom line, Contreras along with many others believe that in order for Texas to prosper and attract good paying industries, public and private sectors must do a better job in funding and providing resources to their poorest regions.

¹ Vicenarians: defined as someone in their 20s (20-29) (Contreras 2020:1).

Theory

A Brazilian educator and philosopher, Paulo Freire was a leading activist of critical pedagogy. This method linked knowledge to action; it encouraged students to look past the issues on paper and to take action for change and development within their society. Students are not restricted to those who sit in a classroom, but rather the members of the community who seek permanent change. In looking at colonias, it is clear that strong communities with strong leaders exist across the Rio Grande Valley, however, the question persists: how can communities be sustainably developed? It is a persistent idea across literature and academia that education is the key to bettering life in colonias. Providing better funding to schools that serve low-socioeconomic communities the chance of students succeeding increases (CPPP 2017: 11). By providing education opportunities to the community the region could see a decrease in health crisis and an increase in literacy and other competing factors. According to the U.S. Census Bureau, 67.2% of adults 25 and older in Cameron County graduate high school, 64.5% for Hidalgo County, and 51.5% for Starr County. These numbers alone do not seem low, but when compared to the state percentage of 83.2% it is evident that the lower Rio Grande Valley is behind in education. In comparing the percentages of a bachelor's degree or higher, 17.3%, 18.4% and 10.3% respectively compared to 29.3% for the State it is clear that an education gap exists. These disparities are linked to the environment in which residents are raised and educated (CPPP 2017:5). In looking at data provided by the Texas Education Agency, patterns associated with economic status are seen in the education of students across the Rio Grande Valley. My hypothesis is if a school district has a higher number of colonias in their area, then they are more likely to see a negative impact on education performances. If proven to be true, the infrastructure of colonias would be the starting point to further community development following the Freire methodology of teaching

through actions. To better the state of Texas as a whole, colonias must become sustainable, viable assets.

Data and Methods

Utilizing data from the Texas Education Agency and the Texas Attorney General Colonias Database the initial analysis will be a simple comparison of the percentage of economically disadvantaged students and the rate of graduation over a five-year period. Following this, a second analysis will analyze the estimated number of colonias in each school district along with any relationship found with data from the initial comparison. Five school districts from each of the three counties were chosen for the study with Starr county as an exception because there are only three school districts in total. The school districts from Hidalgo County include: Donna ISD, Hidalgo ISD, McAllen ISD, Pharr-San Juan-Alamo ISD, and Sharyland ISD. From Cameron County: Brownsville ISD, Harlingen CISD, La Feria ISD, Los Fresnos CISD, and San Benito CISD. From Starr County: Rio Grande City CISD, Roma ISD, and San Isidro ISD. To perform the comparison the data will be input into line graphs to illustrate if there is a trend throughout the five-year period. A trend will be recognized if a relationship between the economic disadvantage percentage the graduation rate is found. This result will then be compared to the number of colonias in each school district to identify if there is a correlation between education performance and residing in a colonias. For the analysis to have greater accuracy, results in each county will be individually analyzed.

Analysis

In each of the three counties a slight correlation was found, however, it was not consistent across all the school districts. The correlation between the percentage of economically disadvantaged students in each district compared to the graduation rate for the class of 2017 was most prominent in the extremities meaning the district with the highest graduation rate and lowest economically disadvantaged population and inversely

the district with the lowest graduation rate and highest economically disadvantaged population. Specifically, in Hidalgo County, Donna ISD and Sharyland ISD in *table 2* depict the correlation described above. This relationship was consistent across the three counties; however, it was not the case for the

Cameron County	
% Economically Disadvantaged Rank	Graduation Rate Rank (2017)
1. Brownsville ISD	1. Los Fresnos
2. La Feria ISD	2. La Feria ISD
3. San Benito	3. San Benito
4. Los Fresnos	4. Brownsville
5. Harlingen CISD	5. Harlingen

Hidalgo County	
% Economically Disadvantaged Rank	Graduation Rate Rank (2017)
1. Donna ISD	1. Sharyland ISD
2. Hidalgo ISD	2. Hidalgo ISD
3. PSJA ISD	3. PSJA ISD
4. McAllen ISD	4. McAllen ISD
5. Sharyland ISD	5. Donna ISD

Table 2

Starr County	
% Economically Disadvantaged Rank	Graduation Rate Rank (2017)
1. Rio Grande City CISD	1. San Isidro ISD
2. Roma ISD	2. Rio Grande City CISD
3. San Isidro ISD	3. Roma ISD

Table 3

majority of the sample. Moving forward the comparison between the number of colonias and the previous relationship was not ideal. The Texas Attorney General Colonia

Database lacked solid information in terms of the number of colonias in each school district, thus an estimation was made. This estimation compared to the results from first analysis also yielded inconclusive results. There was a slight correlation, but it was not consistent enough to confidently confirm that my hypothesis is correct. With further analysis of the data it would be possible to find a stronger association between a school district's education performance and the number of colonias in each district.

Conclusion

Overall, this type of research in colonias is fairly new. Most studies examine the infrastructure of colonias and without studying the impact on other important factors. In looking at all the data provided by the Texas Education Agency, over the five years of focus, it is evident that the region lags behind the average performance of the state and is not improving in the districts with a higher percentage of economically disadvantaged students. To further dissect the education performances of school districts in the three counties a closer examination of the relationship between education and living in a colonia needs to take place. This data, along with a more personalized approach of a survey or interviews within colonias, could help deliver results that could fully answer the research question of this study and produce vital data that could be beneficial to develop more viable and sustainable communities in the Rio Grande Valley.

Sources

- Center for Public Policy Priorities 2017. “State of Texas Children 2017: Child Well Being in the Rio Grande Valley.” *Texas Kids Count Project* October 2017.
- Contreras, Salvador 2020. “Texans in their twenties: a window into the state’s future.” *Border Business Briefs* 16(Spring) 1-4.
- Estes, Mark, Kingsley E. Haynes and Jared E. Hazleton. 1977. “Colonias in the Lower Rio Grande Valley of South Texas: A Summary Report.” *Policy Research Project Reports University of Texas at Austin* 18 (1977).
- Federal Reserve Bank of Dallas 2015. “Las Colonias in the 21st Century: Progress Along the Texas- Mexico Border.” texascolonias.org (June 24, 2020).
- Federal Reserve Bank of Dallas 2016. “Closing the Digital Divide: A Framework for Meeting CRA Obligations.” www.dallasfed.org (June 24, 2020).
- Greater Texas Foundation 2017. “South Texas Regional Overview.” https://www.greatertexasfoundation.org/wp-content/uploads/2017/12/Research-TRAP-_South-Short.pdf (June 24, 2020.)
- Jepson, Wendy, and Heather Lee Brown. 2014. “‘If no gasoline, no water’: privatizing drinking water quality in South Texas colonias.” *Environment and Planning* 46(2014): 1038-1048.
- May, Marlynn L., Gloria J. Bowman, Kenneth S. Ramos, Larry Rincones, Maria G. Rebollar, Mary L. Rosa, Josephine Saldana, Adelina P. Sanchez, Teresa Serena, Norma Viega, Gregoria S. Villegas, Maria G. Zamorano, and Irma N. Ramos. 2003. “Embracing the Local: Enriching Scientific Research, Education, and Outreach on the Texas-Mexico Border through a Participatory Action Research Partnership.” *Environmental Health Perspectives* 11 (October): 1571-1576.

- Mier PhD, Nelda, Chanam Lee PhD, Matthew Lee Smith, MPH, PhD, CHES, Xiaohui Wang, PhD, David Irizarry, Elias H. Avila-Rodriguez, PhD, Laura Trevino, ME, and Marcia G. Ory, PhD. 2013. "Mexican-American Children's Perspectives: Neighborhood Characteristics and Physical Activity in Texas-Mexico Border Colonias." *Journal of Environmental Health* 76 (October): 8-16.
- Olmedo, Carlos, and Peter M. Ward. 2016. "Model Subdivisions: The new face of developer lot sales for low-income colonia-type housing in Texas." *Land Use Policy* 52 (2016): 181- 194.
- Ramos M.D., Irma N., Marlynn May, PhD., and Kenneth S. Ramos, PhD. 2001. "Environmental Health Training of *Promotoras* in Colonias Along the Texas-Mexico Border." *American Journal of Public Health* 91(April): 568-570.

The Connection Between Finance and Corporate Social Responsibility

Angelica Rabago

Mentor: Violeta Diaz, Ph.D.

St. Mary's University, San Antonio, TX

Within the last decade, it has become increasingly important to stakeholders that companies be more socially responsible as part of their operations. With the growing importance to stakeholders, numerous companies have adopted more socially responsible policies and regulations. This research analyzes the association between the financial success of a company and how well they manage their operations with consideration to the environment, society, and company governance. Using the data from companies sets that include their Sustainalytics Rank (a measurement of ESG) as well as measures of financial health such as return on assets and return on equity depicts the association. The purpose of this study is to analyze recent financial data of companies and compare them to their Sustainalytics rank, which has only been recently used to measure how socially responsible a company has been. The objective of this study is to explain if there is a connection between a company's financial performance and its ESG rating, which can be seen in an analysis of the data. Using the Bloomberg database, I gathered various financial and ESG data and analyzed it by using a multiple linear regression; it was with the regression that a p-value and coefficient were found to determine the relationship between financial ratios and ESG ratings. Results show that there is a statistically significant relationship between the financial performance of a company and its ESG rating at the 5% level. Another important finding was the positive coefficient produced from the regression, which indicates a positive connection between the data proving the correlation between all the contributing factors.

Introduction

Within the past ten years, customers are now, more than ever, pressuring companies to adopt more socially responsible corporate practices (Iglesias 2020). With the growing importance to stakeholders, numerous companies have adopted more socially responsible policies and regulations. These corporate practices that customers demand are Corporate Social Responsibility (CSR). CSR in a company is when the company creates policies that coincide with doing good in a social aspect as well as for the company itself (Yuan 2020).

Corporate social responsibility can be measured through an Environmental Social Governance rating (ESG Rating). Each of these aspects is an important measurement of a company's CSR (Etter 2019). Environmental focuses on the company's actions that affect the environment around them, for example, a company recycling and reducing their CO2 emissions as the environment is highly affected by it (Herath 2017). As for the social aspect of ESG, it tends to focus more on how the company interacts with society, which includes anyone that has any interest in the company whether they are customers, investors, or even someone who just lives near where the company is located (CFA Institute 2015). Examples of the social aspect are the company promoting health, protecting its employees, keeping morale high, or maintaining product integrity (Knox 2018). Factors like the ones mentioned are what draws customers to the company and make them returning customers. Once a customer is able to trust a company or respects how they go about business, they tend to favor the company and continue to bring their business there (Iglesias 2020). Lastly is governance, which refers to the way the companies to conduct themselves, for example, with risk management, executive pay, diversity in the workplace, or shareholder rights. This is an important factor in the ESG rating because if a company does not run as efficiently as it could, then it is not likely that it will continue to grow and do well. If the company adopts these principles, in the long run, the company will continue to do well. It is with these factors of Corporate

Social Responsibility that I believe with a higher ESG rating, the more successful a company would be as far as finances (Tsoutsoura 2004).

Significance

Although there has been a growing interest in companies engaging in corporate social responsibility, there is not much research as to whether or not it plays an important role in the financial health of a company. There has been some research and analysis in the past few years, but it is important to continue the research as CSR is still growing in business. In other research, there are different variables used to measure the effects CSR and ESG ratings have on a company's financials. For example, Eliwa (2019) explores the relationship between ESG and financial performance using ROA, size, and profits. Other variables used are market cap and profitability (Khan 2019).

Following previous studies, I also use ROA and size to explore this relationship. In my sample I only include companies that trade in the stock market, therefore I use market capitalization as a proxy for the size of the company. For my research, ROA and market cap were used along with return on equity (ROE) and price-earnings ratio as the independent variables. ROE is an important variable to add as it determines the profit of a company in relation to its shareholder equity (total assets - total liabilities). The

price-earnings ratio is also another important measure of financial health as it shows how a company is valued by stock market investors. These additional measures are significant as there are more variables directly related to the financial health of a company. In contrast to other research, this research has more focus on finances and CSR performance.

Methods

As part of this research, I took a quantitative approach to this data. Through the Bloomberg database, I gathered and filtered data to meet certain criteria. This criterion was obtained

through the equity screening screen In Bloomberg. From there I filtered the companies to have an active trading status, have trading status in the United States, and by different sectors. The different sectors include consumer discretionary/ staples, communications, energy, financials, healthcare, industrials, materials, technology, and utilities. Additional screening criteria included return on assets, return on equity, Sustainalytics rank, market cap, and price-earnings ratio. The Sustainalytics rank is a Bloomberg measurement for the proper ESG rating of a company. My analysis starts on January 2, 2020, so that the data is not a reflection of 2020 as the Covid-19 pandemic severely affected many companies.

After gathering the data from Bloomberg, it needed to be filtered further on excel as some companies did not have a Sustainalytics rank or financial ratio needed to measure the connection between them; these companies were deleted from the data set. With the rest of the data, however, a regression was run where the independent variables were the financial ratios, and the Sustainalytics rank was the dependent variable. The equation for the regression is $ESG\ Rating = ROA(x1) + ROE(x2) + P/E(x3) + Market\ Cap(x4) + Intercept$. From the regression, the important factors to analyze were the p-value and coefficients of the variables. The p-value determines the significance of the results, while the coefficient determines the relationship between the variables, whether they be positive or negative.

Results

According to Table 1, there is the importance of the data as a whole that depicts the Sustainalytics rank in all of the data as having a mean of 48.12. With a mean of this size and the maximum rank being 98.51, it displays just how much improvement there needs to be in regards to a company's social responsibility practices. This can also be the result of not having enough companies participate in these practices and therefore do not have a rank to be analyzed.

Table 1	<i>Sustainalytics Rank</i>	<i>ROA</i>	<i>ROE</i>	<i>P/E</i>	<i>Market Cap</i>
Mean	48.12055659	0.059373	0.206135	29.46356	51.55858998
Standard Error	1.105283761	0.002911	0.015411	1.989108	4.770859782
Median	48.33	0.0463	0.1422	20.52	19.39
Mode	0	0.0636	0.14	12.27	7.43
Standard Deviation	25.66068065	0.067586	0.357794	46.17989	110.7620628
Sample Variance	658.4705313	0.004568	0.128017	2132.582	12268.23455
Kurtosis	-1.031819565	3.206469	47.37585	99.48243	39.32334686
Skewness	0.038187638	0.279656	5.299118	8.870027	5.696595524
Range	98.51	0.6391	5.331	640.41	989.86
Minimum	0	-0.2857	-1.2188	1.62	1.06
Maximum	98.51	0.3534	4.1122	642.03	990.92
Sum	25936.98	32.0023	111.1065	15880.86	27790.08
Count	539	539	539	539	539

Through the regression of all of the sectors, it is clear to see that there is a significance of the data. In Table 2, it notes that the sample of 539 companies being analyzed, there is significance in the ROE and the market cap since their p-value is less than 5%. On the other hand, the ROA and Price to earnings ratio show less significance as the ROA is 8% greater than the 5% requirement and the P/E is only significant at the 10% level. Also, Table 2 displays how the coefficients of each variable are positive, not including the price-earnings ratio.

Table 2				
Summary Output for All Sectors				
<i>Regression Statistics</i>				
Multiple R	0.237954103			
R Square	0.056622155			
Adjusted R Square	0.049555655			
Standard Error	25.01678623			
Observations	539			
ANOVA				
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>Significance F</i>
Regression	4	20058.80311	5014.701	2.80795E-06
Residual	534	334198.3427	625.8396	
Total	538	354257.1458		
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
Intercept	44.37208663	1.681495284	26.38847	7.5281E-99
ROA LF	28.92757521	19.47464602	1.485397	0.138028854
ROE LF	7.308630105	3.672796922	1.989936	0.047107504
P/E	-0.04189321	0.023421773	-1.78864	0.074238937
Market Cap	0.034110743	0.009759688	3.495065	0.00051334

Additionally, it is important to note that when dividing the companies by different sectors the significance decreases along with the sample size. This decrease in sample size can be seen in Table 3 and means there is less to go off in order to determine a proper connection between the sectors' financials and their ESG rating. However, even with this decrease in the sectors, the market cap still displays a p-value that is less than 5%, which still shows some significance. If there were more companies with an ESG rating, it would be easier to display that connection.

Table 3	Consumer		Communications		Energy		Financials		Healthcare	
	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
Intercept	51.37038	0.00000	34.24991	0.00118	42.49458	0.00000	41.89381	0.00000	45.90359	0.00000
ROA	5.64676	0.89006	-66.71373	0.72345	94.73777	0.59937	55.13068	0.43627	9.52920	0.87675
ROE	4.44028	0.45497	28.18979	0.57100	-48.96085	0.54458	15.27763	0.47263	4.97796	0.76239
P/E	-0.13016	0.08269	-0.09521	0.54347	-0.05883	0.15331	-0.02031	0.75549	-0.14558	0.55520
Market Cap	-0.00478	0.77337	0.06723	0.03357	0.02306	0.24303	0.03583	0.21135	0.14715	0.00168
	Industrials		Materials		Technology		Utilities			
	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value		
Intercept	39.01198	0.00011	39.01198	0.00011	49.45265	0.00000	32.20979	0.07783		
ROA	46.09944	0.49422	46.09944	0.49422	-4.34788	0.91953	-825.79600	0.22648		
ROE	1.31751	0.90210	1.31751	0.90210	6.70006	0.26139	108.20752	0.38485		
P/E	-0.53977	0.10846	-0.53977	0.10846	-0.04728	0.20431	1.23767	0.20353		
Market Cap	0.32024	0.00167	0.32024	0.00167	0.21115	0.00053	-0.01279	0.94493		

Conclusion

Given all of the data and analysis, it is clear that there is a connection between a company's financial health and its corporate social responsibility. From the results, there is a significance of the p-values of the ROE and Market Cap as there are less than 5% along with the positive coefficients of the variables, not including the price-earnings ratio. However, it is important to consider the fact that although there was data, this research needs to continue as data become more available. The increase in data availability will be a result of companies continuing to implement corporate social responsibility regulations in policies in their operations. As data becomes more available, I would like to analyze, with more certainty, how directly correlated ESG has on a company's finances.

References

- ADEC ESG Solutions. (2020). What is ESG? Retrieved from <https://www.esg.adec-innovations.com/about-us/faqs/what-is-esg/>
- Eliwa, Y., Aboud, A., & Saleh, A. (2019). ESG practices and the cost of debt: Evidence from EU countries. *Critical Perspectives on Accounting*, 102097.
DOI:10.1016/j.cpa.2019.102097
- Etter, M., Fieseler, C., & Whelan, G. (2019). Sharing Economy, Sharing Responsibility? Corporate Social Responsibility in the Digital Age. *Journal of Business Ethics*, 935–942.
DOI: 10.1007/s10551-019-04212-w
- Herath, H. S. B., Herath, T. C., & Dunn, P. (2017). Profit-Driven Corporate Social Responsibility as a Bayesian Real Option in Green Computing. *Journal of Business Ethics*, 158(2), 387–402. DOI: 10.1007/s10551-017-3705-1
- Iglesias, O., Markovic, S., Bagherzadeh, M., & Singh, J. J. (2018). Co-creation: A Key Link Between Corporate Social Responsibility, Customer Trust, and Customer Loyalty. *Journal of Business Ethics*, 163(1), 151–166.
DOI: 10.1007/s10551-018-4015-y
- Institute, C. F. A. (2015, December). ENVIRONMENTAL, SOCIAL, AND GOVERNANCE ISSUES IN INVESTING. Retrieved from <https://www.cfainstitute.org/-/media/documents/article/position-paper/esg-issues-in-investing-a-guide-for-investment-professionals.ashx>
- Khan, M. (2018). Corporate Governance, ESG, and Stock Returns around the World. SSRN Electronic Journal.
DOI:10.2139/ssrn.3279830
- Knox, B. D. (2018). Employee Volunteer Programs are Associated with Firm-Level Benefits and CEO Incentives: Data on the Ethical Dilemma of Corporate Social Responsibility Activities. *Journal of Business Ethics*, 162(2), 449–472. DOI: 10.1007/s10551-018-4005-0

- Lee, L.-E. (2014, December). 2014 ESG Trends to Watch. Retrieved from <https://www.msci.com/www/webcast/2014-esg-trends-to-watch/013657191>
- Romero, S., Jeffers, A., Lin, B., Aquilino, F., & DeGaetano, L. (2018). Using ESG Ratings to Build a Sustainability Investing Strategy. *CPA Journal*, 88(7), 36–43. Retrieved from <http://web.a.ebscohost.com/blume.stmarytx.edu:2048/ehost/detail/detail?vid=3&sid=5b23dfb7-ea14-44f2-9275-dfeaa692cd5f@sidc-v-sessmgr03&bdata=JnNpdGU9ZWZWhvc3QtbG12ZSZZY29wZT1zaXRl#db=bft&AN=131153459>
- Tsoutsoura, M. (2004). Corporate Social Responsibility and Financial Performance. *UC Berkely School of Business*. Retrieved from <https://escholarship.org/content/qt111799p2/qt111799p2.pdf>
- Yuan, Y., Lu, L., Tian, G., & Yu, Y. (2020). Business Strategy and Corporate Social Responsibility. *Journal of Business Ethics*, 162(2), 359–377. DOI: 10.1007/s10551-018-3952-9

The Last Romantic Composer: A study of the harmonic language of Rachmaninoff

Brandon Ichavez

Mentor: Matthew Mireles, DMA
St. Mary's University, San Antonio, TX

The ethereal music of Sergei Rachmaninoff has been a topic of fascination for many composers and musicians alike. From the seemingly lush melodies carried through by cascades of hill like arpeggios, contrasted with galloping, triumphant chords (as well as many other elements), the music of Rachmaninoff has a familiar, yet distinct color as his music shares elements of famous composers such as Frederic Chopin and Alexander Scriaban, but evolves on those elements through a variety of techniques.

While Rachmaninoff has many works, the prelude serves a significant role in the overall construction of his compositional technique. "Preludes were a platform on which to display virtuosity, reference other genres, explore the limits of the instrument, and develop a single idea to the maximum, while being concise and economical in structure."¹ It is through the preludes Rachmaninoff displays his wide range of compositional (and technical) abilities. The preludes of Opus 23 and 32 are perhaps the most famous of his solo piano works, as they show the widest range of Rachmaninoff's compositional palette. For the purpose of keeping consistency, this essay will focus primarily (but are not limited to) on the preludes of Op.23 no. 5 and Op. 32 no. 10, and their significance to Rachmaninoff.

There is a historical significance associated with *Prelude in B minor*, Op. 32 no.10, that has deep nostalgic emotions, as well as an actual source of inspiration that we currently know about. In a dissertation by Robert S. Buxton, a conversation

¹ Roh, Yoon-Wha. "A Comparative Study of the Twenty-Four Preludes of Alexander Scriabin and Sergei Rachmaninoff," 2015.

between pianist Benno Moiseiwitsch and Rachmaninoff discusses the prelude after a performance and the significance behind the piece. The end of the account goes as follows:

“So despondently, I sat down on the chair, and I said ‘Well to me it suggests a return,’ whereupon a long arm shot out, ‘Stop!’ So I said ‘Why, what have I done?’ He said ‘That’s what it is, it’s the return.’¹ It was an exile, and that’s what Rachmaninoff was.”

Buxton goes on to discuss the “sadness and nostalgia that both he and Rachmaninoff felt for the Russia of their youth” and how they fled Russia to escape the communist revolution.² Buxton also mentions that despite the prelude depicting an exile, the piece was completed 1910, roughly 7 years prior to them leaving Russia. From this we can assume the nostalgia he felt had a much different meaning at that time. Most likely those reminiscent feelings evolved into a deeper longing after they fled Russia.



Die Heimkehr (1887) by Arnold Böcklin

² Robert S Buxton, “MUSICAL TIME AND MEMORY: A BERGSONIAN INTERPRETATION OF SERGEI RACHMANINOFF’S PRELUDE OP. 32 NO. 10 IN B MINOR” (dissertation, 2018). 2

The prelude was also inspired by a painting *Die Heimkehr* (The Return), by Arnold Böcklin³, in which the painting depicts a man dressed in red, gazing upon a house, shrouded by trees, with a warm light, glowing from the window of the house. He is reflected by the glistening water and the cloudy sky. So much warmth, color, and life in the painting but only one person present, him. No people or birds or animals, only “the man apparently overcome with a flood of memories upon returning home.”⁴ Exploring deeper into the narrative of what this painting might depict, we can see that it is supposed to be a man returning home, however there is more than just the literal meaning. The long journey of returning home symbolizes death, for “the man in the painting is in the autumn of his years and the dam with its water is really a store of spiritual energy and inspiration he has been able to accumulate during life - the square is the symbol for the Earth - the physical.”⁵

The painting adds a new dimension to the piece that deeply embeds it with not just a nostalgic longing that Rachmaninoff felt, but a universal sense of nostalgia that everyone can feel. It’s obvious to see how this was his favorite prelude with how emotionally connected he was to the work.

As for *Prelude in G minor*, there is not so much emotional or historical significance for Rachmaninoff himself, however the popularity the prelude garnered make it to this day one of the most performed preludes of the Op.23 set. *Prelude in G minor* was written in 1901, 2 years previous to the other 9 preludes of

³ Arnold Böcklin, *Die Heimkehr*, 1887, painting, private collection, public domain photograph from "Von Anker bis Zünd, Die Kunst im jungen Bundesstaat 1848–1900", Kunsthaus Zürich: 1998, upload December 2008, accessed November 11, 2016, https://commons.wikimedia.org/wiki/File:Böcklin_Die_Heimkehr_1887.jpg

⁴ Ibid 5

⁵ www.mezanet.nl Mezanet Interactieve Media, “Observations Placeholder,” All About Heaven - Observations placeholder, accessed June 1, 2020, <https://allabouttheaven.org/observations/boecklin-arnold-die-heimkehr-the-homecoming-or-the-return-1887-024387/221>.

Op. 23. Rachmaninoff premiered this piece and prelude no.1 & 2 in Moscow, February 10, 1903. ⁶ The prelude overall features some of Rachmaninoff’s most extensive use of chords and arpeggios, in terms of complexity and width, as “his hands were famously gigantic – he could reach **over an octave and a half** on a piano with his hands.”⁷

Every composer has their way of writing, just as everyone has their own distinct handwriting, or how an artist has a specific style in their art. Rachmaninoff has a very unique way of writing that was influenced by famous composers such as Chopin, Scriabin, Liszt, Tchaikovsky, and others. In observing what makes Rachmaninoff sound unique, we can see that just as in all composers, there are patterns in his compositional technique that give his preludes the peculiar sound that is Rachmaninoff.

The first of those patterns is Rachmaninoff’s use of extensive arpeggios. Throughout his preludes, he uses long, hill-like, flowing arpeggios that underline chord structure through connecting chords with extensions, common tones, and chromaticism.

As seen in the G minor prelude, the middle section of the prelude features this trait in the left hand (bass clef) as a D major chord is outlined that connects to a Cm6/9 chord through usage of common tone connection.



⁶ Norris, Geoffrey, "Rachmaninoff", Schirmer Books, 1993, 170.

⁷ "21. Rachmaninov – Prelude in g Minor, Op. 23 No. 5." asiyclassical, March 22, 2012. <https://asiyclassical.wordpress.com/2012/03/22/21-rachmaninov-prelude-in-g-minor-op-23-no-5/>.

Just a few systems after Rachmaninoff's use of chromaticism to connect moving arpeggiated lines provides momentum and tension in this lyrical bridge that ends up repeating the beginning of this section, but with slight variation and a different ending phrase.



All of these moving notes outline some kind of chord structure. If we observe the way Rachmaninoff voices these chords, we can find 2 distinct voicings that appear throughout the entire Op.23 set. One of these voicings is a triad with a 4th placed above or below the triad.



The beginning of the lyrical bridge in *Prelude in G minor* features this voicing in the treble clef in both forms. This voicing appears much throughout the lyrical section as well as the march like beginning and ending.

Prelude in B minor also uses such in its swelling of tension through harmony in the middle section of the piece, as Rachmaninoff moves through chords with this voicing. The

second voicing also appears in this example, which is a pair of thirds separated by an interval of a fourth. These two chord voicings are the staple for Rachmaninoff's compositional palette.



A passage that utilizes these two chord voicings in succession can be seen in the g minor prelude as Rachmaninoff moves from an Eb major chord to Bb Major and then to D minor.



Using just these three chords, Rachmaninoff extends a small musical idea and outlines a progression through the use of changing voicings.

It is also in this passage that we see one of his most used rhythms, two sixteenths followed by an eighth. It is this galloping rhythm that Rachmaninoff uses to drive pieces with momentum (rhythmically) and oftentimes pushes/pulls at tension with his use of harmony. The G minor prelude is based primarily around this rhythm, as it can be seen everywhere (except in the lyrical bridge). Another rhythm used just as often is the triplet rhythm, where rachmaninoff will move through chords in triplets or outline chords with notes in triplets.

The middle section of the B minor prelude uses chords in triplets to swell tension through rhythm, dynamics, and harmony. Oftentimes the chords will be extensive in depth, whether that be

a slow passage such as the one above, or cascading through chords at remarkable speed.

Perhaps the most important trait of Rachmaninoff's music is his use of melodicism in terms of harmonic progressions and how it layers over the previous traits. The beautiful, soaring



melodies that are placed over (or embedded inside) the complex array of accompaniment indeed have a lush, but nostalgic or melancholic quality.



If we dissect the bridge melody in the G minor prelude, we can see tugging and pushing at major/minor chords, with two D major chords, followed by a Bb augmented chord leading into a D dominant 7 chord, setting the listener up with the V7 chord in g minor, a chord filled with angst and tension that wants to go somewhere harmonically. Rachmaninoff then walks down into the Bb+ chord and into the vi chord (c minor), in which he then uses passing tones to lead us to a Bb octave that seems like it would be a restatement of the Bb+ chord. However he chooses to use the V7 (D dominant 7) chord in a different inversion that does not contain the fifth just like the previous instance of such. Then as the A octave arrives, it gives us the sense of a resolution, but not quite fully as it is a half cadence. His use of counterpoint also

establishes a clear focal point and gives this melody the musical interest it needs. With so many qualities in just this short phrase, we can see just how Rachmaninoff's brilliant use of melodicism gives his melodies the grandiose yet melancholic attribute.

It is through these elements and Rachmaninoff's creativity that his music achieves the wide range of color. Sounds from lush and playful, to emotional and intense, the music of Rachmaninoff has such sophistication and complexity, it is easy to become engulfed in such, as it can take the listener on an endeavor. An endeavor that has so many conflicting emotions and passion. Qualities like this are what makes his music so remarkable and memorable that garnered Rachmaninoff his place in history as his pieces are still played today 100+ years after being written.

Bibliography

Roh, Yoon-Wha. "A Comparative Study of the Twenty-Four Preludes of Alexander Scriabin and Sergei Rachmaninoff," 2015.

"21. Rachmaninov – Prelude in g Minor, Op. 23 No. 5." asiyclassical, March 22, 2012.

<https://asiyclassical.wordpress.com/2012/03/22/21-rachmaninov-prelude-in-g-minor-op-23-no-5/>.

Mezanet Interactieve Media, www.mezanet.nl. "Observations Placeholder." All About Heaven - Observations placeholder. Accessed June 25, 2020.

<https://allaboutheaven.org/observations/boecklin-arnold-die-heimkehr-the-homecoming-or-the-return-1887-024387/221>.

Norris, Geoffrey, "*Rachmaninoff*", Schirmer Books, 1993

"MUSICAL TIME AND MEMORY: A BERGSONIAN INTERPRETATION OF SERGEI RACHMANINOFF'S PRELUDE OP. 32 NO. 10 IN B MINOR," 2018.

Rachmaninoff, Sergei, *Prelude in B minor no. 10, Opus 32*, 1910

Rachmaninoff, Sergei, *Prelude in G minor no. 5, Opus 23*, 1901

Accurate Evaluation amidst Correlated and Rampant Flunking: The Power of the Independent-Samples t -Test with Nonrandom Missingness in Skewed Populations

Sequoia N. Callahan

Mentor: Rick Sperling, Ph.D.
St. Mary's University, San Antonio, TX

School mobility can produce nonrandom missingness in within-subjects designs – a problem that interferes with teachers' ability to evaluate student progress over time. Previous studies have explored the independent-samples t -test and the one-way ANOVA as superior methods of analyzing longitudinal classroom data with high missingness, but those studies were limited to cases where scores were normally distributed (Aquino Aguilar, 2017; Callahan, Castro & Walls, 2019; Marquez-Muñoz, 2019). In real life situations, classroom data rarely fall along a perfect normal curve, instead tending toward skewed distributions. The phenomenon of positively skewed distributions is commonplace in schools with high mobility wherein many students score at the tail end of the distribution resulting in a floor effect. In this study, I used a Monte Carlo simulation to evaluate the statistical power and type-I error of the independent-samples t -test under varying correlations, skews, and mean differences. Results indicate that the independent samples t -test maintains adequate power under conditions of low to moderate skew. However, type-I error rates typically exceeded nominal rates as correlations increased. Even though the independent-samples approach has been shown to have advantages when used with normally distributed data, it would be irresponsible to use to evaluate classroom progress. Educators are also cautioned against drawing essentialist conclusions about low scoring students. Recommendations for increased use of varied and authentic assessment are discussed. Keywords: Missing data, education, school mobility

Due to the powerful forces of systemic oppression, race and ethnicity are intertwined with socioeconomic status (SES). Racial/ethnic minority students are more likely than White students to be living in higher levels of poverty, and “high-poverty” schools are almost always “high-minority” schools (Orfield & Lee, 2005). In the following sections, I will explain how these problems affect teachers’ ability to accurately evaluate classroom progress and, in turn, their own pedagogical effectiveness. I will also explain when statistical tests that are typically used for comparing two or more independent groups, like the one-way ANOVA and the independent-samples *t*-test, would be expected to be superior to more traditional methods of analyzing within-subjects data.

Literature Review

Causes of Poorer Academic Achievement

In K-12 education, race/ethnicity and SES strongly correlate with academic achievement, which can be attributed to a variety of factors both within and outside the school. The most prominent contributing factor is the quality of education students receive. Minority and low-SES students commonly attend poorly funded schools with limited resources. Tools essential to learning, such as books and writing materials, are scarce (Friedman-Krauss & Raver, 2015). Teacher quality is also significantly lower in high-poverty/high-minority schools (Desimone & Long, 2010; Friedman-Krauss & Raver, 2015; Peske & Haycock, 2006). Students in these schools are taught by teachers who exhibit poor pedagogy and limited mastery of content, and in many cases, surprisingly weak literacy and numeracy. According to a report by The Education Trust, many teachers who primarily educate minority and low-SES students lack a major, or even a minor, in the area they teach (Peske & Haycock, 2006). Many also score lower on literacy and vocabulary (Peske & Haycock, 2006). Not provided with the necessary tools and conditions for success, students’ academic achievement suffers.

In addition to having limited access to quality education, minority and low-SES students face considerable disadvantages

outside of school. Children in poverty are more likely to experience food instability, family turmoil, and violence (Evans, 2004). Not only does this cause significant distraction from academics, it also hinders healthy development during critical stages in early life resulting in cognitive dysregulation. Cognitive dysregulation characterizes impairment of a variety of skills that are important for learning such as attention, working memory, and inhibitory control (Friedman-Krauss & Raver, 2015).

Although the off-campus environments of low-SES and minority students can contribute to attenuated academic achievement, recent studies have shown that exposure to a quality education can offset the negative effects of poverty-induced trauma. As reported in The Education Trust, high-poverty schools with high-quality teachers had nearly twice as many students pass standardized tests as high-poverty schools with low-quality teachers (Peske & Haycock, 2006). This suggests that education reform focused on equal distribution of resources and quality teachers can help to equalize achievement outcomes between minority and nonminority students.

School Mobility and Dealing with “Missingness”

A phenomenon that closely relates to race, ethnicity, and socioeconomic status is school mobility. School mobility, the act of changing schools, is more common among low-SES and minority students and is also associated with lower academic achievement (Friedman-Krauss & Raver, 2015; Rumberger, 2003; Welsh, 2018). In a longitudinal study of low-income, racial/ethnic minority students, children’s math achievement and mobility were tracked over a 5-year period from Head Start (preschool) to fourth grade. An inverse relationship was found between the number of times students changed schools and math achievement in fourth grade (Friedman-Krauss & Raver, 2015). The effects of school mobility, like poorer academic achievement and negative behavioral outcomes, are also more pronounced among students within these demographics (Han, 2014; Rumberger, 2003). Changing schools during a school year causes students to miss tests and other major assignments, which results

in missing grades, a phenomenon that in the context of within-subjects analyses is referred to as “missingness”.

If low-SES and minority students demonstrate lower academic achievement and greater school mobility, it appears logical that students who score low on initial tests are more likely to miss subsequent administrations of tests thus contributing to higher rates of missingness within those groups. Teachers attempting to analyze student data in order to evaluate classroom progress have trouble doing so when missing values are scattered throughout the data both because of diminished statistical power and because observed results are less representative of the overall population of students exposed to their teaching. Typically, statistical tests that analyze longitudinal (e.g., pretest and posttest) data require missing values to be handled in some way in order to compute the results. A common practice that teachers use is listwise deletion. Listwise deletion removes cases that contain a missing value at any point of measurement. As an example, Johnathon received a 55 on the pretest but missed the posttest because he moved schools. Johnathon, along with all his scores, would simply be deleted from the dataset, and the remaining data would be analyzed. Though this method may be easy and efficient, it usually results in a loss of statistical power - the ability of a statistical test to accurately detect an effect (Graham, 2009; Schafer & Graham, 2002). This means that teachers would be less likely to accurately determine if their teaching strategies had a positive or negative effect on their students’ academic outcomes.

The extent to which listwise deletion is problematic depends on the pattern of missingness within the data. Data can either be missing completely at random (MCAR), missing at random (MAR), or missing not at random (MNAR). MCAR simply means that missingness is truly randomly dispersed throughout the data in that missingness does not depend on observed values across the dataset nor what the value would have been had the respondent provided a value. MAR means that missingness depends on observed data but not on

unobserved/missing data within the variable. Finally, MNAR means that missingness depends on other values within the dataset (Graham, 2009; Schafer & Graham, 2002). The phenomenon in which low-scoring students display higher rates of missingness qualifies as MNAR both because students who would have likely scored low on the post-test more often miss that test and because their value is predictable from pre-test scores. This means that the likelihood of missingness depends on what the missing value would have been as well as unobserved data like race, ethnicity, and SES. When teachers use listwise deletion, they are disproportionately deleting the data of low-SES and minority students, making overall evaluations of student progress unrepresentative of a classroom's true population. This causes inadvertent inflation of effect size and may lead teachers to believe that their teaching is more effective than it actually is.

More sophisticated methods of missing data analysis include maximum likelihood estimation and multiple imputation (Graham, 2009; Schafer & Graham, 2002). However, these methods are complex, and most K-12 teachers lack the statistical knowledge needed to perform them. Multiple studies have explored a potential solution to this problem: the use of the one-way ANOVA (OWA) or the independent-samples *t*-test to analyze within-subjects data with missingness (Aquino Aguilar, 2018; Callahan, Castro, & Walls, 2019; Marquez-Muñoz; Sperling, Zwahr-Castro & Cruz, 2017). Traditionally, these tests are used when comparing independent/unrelated groups while the repeated-measures ANOVA (RMA) and the paired-samples *t*-test are used when comparing the same group across different time periods. The RMA and paired-samples *t*-test are preferred when analyzing within-subjects data because they draw statistical power from correlations between measurement points. This occurs because some of the total variation across scores can be accounted for by the fact that the same person contributed scores at both measurement points. However, when RMA and paired-samples *t*-test delete cases rather than impute missing values, statistical power is diminished because the size of the sample is

diminished. Marquez-Muñoz's (2019) study comparing the independent-samples and paired-samples *t*-test drives home this point. The data from her study not only revealed higher statistical power for the independent-samples *t*-test with high missingness and low to moderate levels of correlation between the pretest and posttest, but also lower type-I error for the independent-samples *t*-test (Marquez-Muñoz, 2019).

Skew and Classroom Data

An important limitation of previous studies comparing the OWA and the independent-samples *t*-test to RMA and paired-samples *t*-test is that they assumed that classroom data ordinarily conform to a normal distribution (Aquino, 2018; Callahan, Castro & Walls, 2019; Marquez-Muñoz, 2019). In a normal distribution (or Gaussian curve), the majority of scores are concentrated in the middle of the distribution around the mean. In reality, data do not always fall along a perfect normal curve. Sometimes, data are positively or negatively skewed in which the majority of scores are concentrated in the far left (i.e., lower scores) or far right (i.e., higher scores) of a distribution. For example, Pollard-Durodola et al. (2016) and Zhu & Gonzalez (2017) found significant floor effects in their studies on the effects of a certain curricula on vocabulary test scores among low-SES Hispanic preschool children. The authors note that when a majority of children score well below the mean on vocabulary assessments, traditional statistical analyses can produce biased results (Pollard-Durodola et al., 2016; Zhu & Gonzalez, 2017).

Another method of handling skewed data is the common practice of “grading on a curve”, meaning that if student data are skewed a teacher may make adjustments so that the data fit a normal curve. However, altering the nature of a student data distribution may not be a good idea. Kulick and Wright (2008) found that curving grades introduces a “luck factor” whereby student grades depend less on student preparedness and more on random chance. This means that two students with similar levels of preparedness for an exam could end up with wildly different grades (Kulick & Wright, 2008). Furthermore, tampering with

grades so they fit a normal distribution can create biased results due to artificial grade inflation/deflation. Because of these reasons, teachers need other options for handling skewed data.

The purpose of the present study is to determine whether the independent-samples *t*-test is an effective and accurate means of analyzing skewed, within-subjects data with nonrandom missingness in diverse educational settings. Through a Monte Carlo simulation study, the power and type-I error of the independent-samples *t*-test are evaluated using data with varying skews, mean differences, and magnitudes of correlation. A Welch's *t*-test is used for the independent-samples because sample sizes between the pretest and the posttest are unequal as a result of ignoring missing values on the posttest. If the independent-samples *t*-test maintains high power and low type-I error even when analyzing skewed data, this will support its versatility as an evaluation tool for educators who teach diverse student populations.

Method

Sample

A Monte Carlo simulation study was conducted to produce longitudinal data representing student scores in a pretest/posttest scenario. The data included 72 sets of 1,000 samples of z-scores representing low, moderate, and high magnitudes of correlation ($r=0.0, 0.15, 0.3$), skew (0.0, 0.1, 0.2, 0.4), and mean difference ($\mu = 0.0, 0.05, 0.10, 0.15, 0.20, 0.25$). The sample size was set to 100. Nonignorable missingness was introduced by creating a biserial correlation between missingness and the value of scores on the pretest, such that the lower a student scored on the pretest, the more likely it was that the student would be absent for the posttest. The overall percentage of missing scores on the posttest was set to 25%. Previous studies have simply cut scores in half, labeling the bottom 50% of pretest scores as "low-scorers" and the top 50% of scores as "high scorers." A fixed percentage of low-scorers on the pretest presented missing values on posttests (Callahan, Castro & Walls, 2019). This study uses a correlation between missingness and the

value of scores on the pretest to simulate a more realistic relationship.

Procedure

The independent-samples *t*-test was conducted by treating the pretest and posttest as separate groups of individual scores rather than the same group tested multiple times. It deleted or “ignored” the missing values, simply assuming that all scores were from different students at both measurement points. This results in differing samples sizes between the pretest and posttest, so a Welch’s *t*-test (as opposed to a student’s *t*-test) was used, which assumes variances are unequal. Using an alpha level of 0.05, the type I error and statistical power were calculated under the varying conditions.

Results

As shown in Tables 1-3, the independent-samples *t*-test maintained high statistical power for most of the conditions. As expected, statistical power increases as mean difference increases. Interestingly, statistical power also increases slightly as skew increases, suggesting that skew does not adversely affect the statistical power of the independent-samples *t*-test.

It is also interesting to note the gain in statistical power and the significant inflation of type-I error as correlation increases, specifically when correlation improves to 0.3. It would be expected that the power of a paired-samples *t*-test would increase as correlation increases since the paired-samples *t*-test draws power from higher correlations between measurement points. However, the independent-samples *t*-test treats each measurement point as a separate group of individuals, making it unable to draw power from correlations between groups. The cause of this inflation and increase in statistical power is unknown, and future research should examine this phenomenon.

Discussion

When analyzing skewed data with nonrandom missingness, the independent-samples *t*-test still maintains high statistical power. The skewness of data did not negatively impact power or type-I error, providing evidence that the independent-

samples *t*-test is robust against violations to the normality assumption. This means that the independent-samples *t*-test is a viable option for teachers attempting to analyze student data wherein a majority of scores lie below the mean. However, the inflation of type-I error is a significant problem that educators should be aware of before using the independent-samples *t*-test to analyze within-subjects data. If the magnitude of correlation between pretest and posttest data is high, type-I error is likely to be inflated beyond the nominal 0.05 alpha level, meaning there is a higher likelihood of teachers mistakenly concluding that their students did significantly better when in reality, they did not.

A significant limitation of this study is that 0.4 was the highest value of skew that was tested. The BinNonNor package in R statistical software was unable to successfully perform the *t*-test with a skew any higher than 0.4. Although 0.4 is a moderately high skew, future research should attempt to figure out a way to replicate this study with more extreme skewness. Another limitation is that the sample size was set to 100 which is not representative of a typical classroom, and future studies should consider investigating a more diverse set of sample sizes. Lastly, this study was limited in that it used simulated data. The relationship between student grades on a pretest and missingness on a posttest may differ in real-world scenarios as well as skew, sample size, and correlation. This study must be repeated using real-life data to ensure the effectiveness of the independent-samples *t*-test.

Previous Monte Carlo simulation studies did not reveal an increase in statistical power and type-I error for the independent-samples *t*-test as the magnitude of correlation between data increased. The independent-samples *t*-test still maintained low type-I error even under high levels of correlation (Aquino Aguilar, 2018; Callahan, Castro & Walls, 2019, Marquez-Muñoz, 2019). The reasons for why type-I error inflation occurred under higher levels of correlation in this study is still unclear. It may be caused by the biserial correlation created between student scores on the pretest and missingness on the posttest. If this is the case,

future research should attempt to unpack this issue to determine when type-I error does and does not remain within a reasonable range.

Once these problems and limitations are addressed, the independent-samples *t*-test may still prove to be a viable option for teachers analyzing skewed classroom data with nonrandom missingness. The skew of data did not negatively affect statistical power or type-I error. These results are promising and suggest that the independent-samples *t*-test could be used as a future tool for teachers in diverse educational settings.

It is important to understand that racial/ethnic minority and low SES students' academic outcomes are not solely due to mobility and other poverty-related factors. The education system has a duty to its students to provide equal access to educational resources and fair implementation of assessment. Educators should strive to understand the student populations they serve, including their cultural backgrounds as well as societal impacts of racism and oppression that affect students' performance within European-centric educational settings. Curricula and teacher instruction should "reflect the cultures of their students and [help] students become more aware of and knowledgeable about their own cultures and the cultures of others" (Hood, 1998, p. 189). Additionally, culturally responsive performance-based assessments should be used to accurately assess academic progress in diverse classrooms. These assessments should be "responsive to cultural differences and adequately assess the content-related skills that are the focus of assessment" (Hood, 1998, p. 192). Culturally responsive education allows for students' academic outcomes to depend less on outside forces and more on actual ability, creating a more equitable educational environment. Educators who teach within high-poverty and high-minority schools should keep these ideas in mind when evaluating their students' progress with tools such as the independent-samples *t*-test. Evaluation can only make one aware of potential problems, action works to resolve them.

References

- Aquino Aguilar, G. A. (2017). The relative advantage of one-way ANOVA to repeated measures ANOVA with high student turnover. *McNair Scholars Research Journal*, *10*(1).
- Callahan, S., Castro, M., Walls, M., (2020, April). *Closing the evaluation gap: One-way ANOVA as a solution to non-random missingness in diverse classrooms*. Poster presented at the annual Teachers College Winter Roundtable Teaching to Transform: Mentoring and Supervision in Psychology and Education, New York, NY.
- Desimone, L., & Long, D. A. (2010). Teacher effects and the achievement gap: Do teacher and teaching quality influence the achievement gap between black and white and high- and low-SES students in the early grades? *Teachers College Record*, *112*(12), 3024–3073. retrieved from:
[http://web.b.ebscohost.com.blume.stmarytx.edu:2048/ehost/detail/detail?vid=3&sid=7312997f-378d-424f-8e1a-](http://web.b.ebscohost.com/blume.stmarytx.edu:2048/ehost/detail/detail?vid=3&sid=7312997f-378d-424f-8e1a-T1zaXRI#AN=EJ913412&db=eric)
- Evans, G. W. (2004). The environment of childhood poverty. *American Psychologist*, *59*(2), 77–92.
 doi:10.1037/0003066x.59.2.77f1065011d342%40sessionmgr103&bdata=JnNpdGU9ZWhvc3QtbGl2ZS5zY29wZT1zaXRI#AN=EJ913412&db=eric
- Friedman-Krauss, A. H., & Raver, C. C. (2015). Does school mobility place elementary school children at risk for lower math achievement? The mediating role of cognitive dysregulation. *Developmental Psychology*, *51*(12), 1725–1739. doi:10.1037/a0039795
- Graham, J. W. (2009). Missing data analysis: Making it work in the real world. *Annual Review of Psychology*, *60*(1), 549–576. doi:10.1146/annurev.psych.58.110405.085530
- Han, S. (2014). School mobility and students’ academic and behavioral outcomes. *International Journal of Education Policy and Leadership*, *9*(6).
 doi:10.22230/ijjepl.2014v9n6a573

- Hood, S. (1998). Culturally responsive performance-based assessment: Conceptual and psychometric considerations. *The Journal of Negro Education*, 67(3), 187-196. <https://doi.org/10.2307/2668188>
- Kulick, G., & Wright, R. (2008). The impact of grading on the curve: A simulation analysis. *International Journal for the Scholarship of Teaching and Learning*, 2(2). doi:10.20429/ijstl.2008.020205
- Marquez-Muñoz, J. (2019). An extension of the independent samples t-test for pre-test/post-test data: The case of MNAR. *McNair Scholars Research Journal*.
- Morrissey, T. W., Hutchison, L., & Winsler, A. (2014). Family income, school attendance, and academic achievement in elementary school. *Developmental Psychology*, 50(3), 741-753. doi:10.1037/a0033848
- Orfield, G., & Lee, C. (2005). Why segregation matters: Poverty and educational inequality. *The Civil Rights Project*. Retrieved from <https://www.civilrightsproject.ucla.edu/research/k-12-education/integration-and-diversity/why-segregation-matters-poverty-and-educational-inequality/orfield-why-segregation-matters-2005.pdf>
- Peske, H. G., & Haycock, K. (2006). Teaching inequality: How poor and minority students are shortchanged on teacher quality. Washington, DC: *The Education Trust*. Retrieved from <https://files.eric.ed.gov/fulltext/ED494820.pdf>
- Sperling, R., Zwahr-Castro, J., & Cruz, F. (2017). *The (dis)advantage of paired samples t-test with high missing data: Addressing a perennial problem in our K-12 schools*. Poster presented at
- Zhu, L., & Gonzalez, J. (2017). Modeling floor effects in standardized vocabulary test scores in a sample of low SES Hispanic preschool children under the multilevel structural equation modeling framework. *Frontiers in Psychology*, 8. doi: 10.3389/fpsyg.2017.02146

Table 1

Number of Significant Differences out of 1,000 Iterations for a skew of 0 (normal distribution)

Correlation	Mean Difference	Independent <i>t</i> -Test
0	0	52*
0	0.05	53
0	0.1	112
0	0.15	161
0	0.2	288
0	0.25	369
0.15	0	82*
0.15	0.05	113
0.15	0.1	214
0.15	0.15	330
0.15	0.2	492
0.15	0.25	608
0.3	0	179*
0.3	0.05	294
0.3	0.1	403
0.3	0.15	588
0.3	0.2	707
0.3	0.25	821

Note. * = type-I error

Table 2

Number of Significant Differences out of 1,000 Iterations for a skew of 0.2

Correlation	Mean Difference	Independent <i>t</i> -Test
0	0	53*
0	0.05	49
0	0.1	100
0	0.15	181
0	0.2	265
0	0.25	381
0.15	0	77*
0.15	0.05	113
0.15	0.1	228
0.15	0.15	341
0.15	0.2	473
0.15	0.25	604
0.3	0	175*
0.3	0.05	264
0.3	0.1	436
0.3	0.15	568
0.3	0.2	723
0.3	0.25	842

Note. * = type-I error

Table 3
 Number of Significant Differences out of 1,000 Iterations for a skew of 0.4

Correlation	Mean Difference	Independent <i>t</i> -Test
0	0	42*
0	0.05	54
0	0.1	108
0	0.15	151
0	0.2	255
0	0.25	361
0.15	0	76*
0.15	0.05	129
0.15	0.1	232
0.15	0.15	325
0.15	0.2	429
0.15	0.25	612
0.3	0	146*
0.3	0.05	278
0.3	0.1	403
0.3	0.15	575
0.3	0.2	700
0.3	0.25	846

Note. * = type-I error

The Competitiveness of Generation Z in Self-Directed Investing: The SWOT Analysis

Eric I. Ortega Rodriguez

Mentor: Jialin Zhao, Ph.D.

St. Mary's University, San Antonio, TX

The purpose of the Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis study is to explore the benefits and risks regarding the self-directed investments made by the youth. Self-Directed investing has gained much popularity due to commission-free applications that allow the individual to invest in stock and currencies, which before was completely unheard of. This paper uncovers new information that has yet to be found among business journals. The importance of the study is to allow young investors to have full knowledge of the benefits and consequences of investing in the stock market. In addition to this, this study offers a full breakdown of each of the SWOT main composites and breaks down each section into a more comprehensive piece, allowing a proper examination of the factors that are in and out of control of the investor. This study also makes suggestions on whether a young investor should participate in high-risk investments rather than other forms of lower-risk investments that have a higher probability of return at the cost of a lower amount.

Introduction

As technology continues to develop, so do the means that allow tasks to be completed more efficiently. The same is applied to the way stocks are now purchased. In 2020, during the COVID-19 pandemic, stock purchasing companies such as Robinhood gained over 3 million new users because of decrease share prices that attracted the attention of many young investors (Klebnikov). These young investors usually have no prior knowledge of stock trading and lack exposure to the fluctuating and high-risk trend of the stock market. The methodology used throughout the entirety of this research study is placed under the

strengths, weaknesses, opportunities, and threats analysis lens (SWOT). First, there is context given on the SWOT method which is a prominent analysis method used by corporations when facing any internal or external issues. Such issues range from different departments within the organization such as finance, accounting, marketing, and management departments. By applying the SWOT methodology, it allows the youth to obtain a more comprehensive understanding of both the internal and external benefits. As well as the risks that come along self-investing in stock and gain full insight on whether to invest in the competitive stock market, therefore also creating a “cost-benefit” form of measurement so the young investor can create a strong decision whether they want to partake in the stock market which is typically investments that are of “high risk” that lead to a major gain or loss. The absence of research in this area focused on the youth makes this information crucial to avoid the young generation from making substantial financial mistakes. This research allows the young generation to fully comprehend the responsibility and requirements of self-directed investments. Following this section, the methodology of this paper is presented. Then the application of SWOT to the research topic on hand is discussed.

Methodology

This paper employs the SWOT analysis. The SWOT analysis method was created in the 1960s by Albert Humphrey. Humphrey was a researcher at Stanford University conducting studies with data from top companies in an effort to find out why company planning resulted in failures (Morrison). He ultimately looked at the key areas of the businesses and figured out the four critical components in any business or strategic plan: strengths, weaknesses, opportunities, and threats.

The idea of the SWOT method stems from SOFT analysis. “S” being areas in which the entity is satisfied within the present time, “O” is the opportunities that can be explored in the future, “F” are the faults in the present time, and “T” are the

threats which could arise in the future (Thakur). The transition to SWOT began in Britain where it was being promoted and ultimately extended to strategic planners across the world and is currently helping management consultants achieve corporate goals. In the 1980s, SWOT became an essential method in any field when strategic planning is taking place.

SWOT analysis is applied by those in business who are planning to reach specific goals such as appeal to a new market, expanding a business, or used by startups to enter a market. Within the SWOT method, strengths and weaknesses are internal factors that are usually a reflection of the company, individual, or entity that the analysis is being performed on. These two convey what the entity has to offer and what it lacks. Within corporations, this includes financial, physical, human, and natural resources (Schooley). The remaining two of the method are opportunities and threats which are external factors. These two highlight the positives or negatives that are out of control of the company, including market & economic trends, funding, demographics, and political factors. Once all four areas are taken into consideration, the planning accurately reflects an obtainable goal that aligns with key aspects of the entity. Consequently, creating a plan of action that targets a solution to solve the detailed problem the corporation is up against.

The SWOT Analysis

Strengths

The first aspect of this analysis is examining the strengths that the youth has control of. Also referred to as positive internal factors.

Age Advantage

The first strength for the youth is their young age. Through a concept called "100 Minus Your Age" (Arnott). It is concluded that a younger individual will stay with their investment through ups and downs because they have more time to recover from a possible failure. This also indicates that because the investors are young, they can start building their portfolio: a

starter portfolio. These funds are typically of less risky and as a beginner, the individual has more time to recover from any potential losses they may incur. In addition to this, with the introduction of the internet and mobile applications, accessibility to starter portfolios and stock investments is facilitated.

Technological Knowledge

Another strength that comes with being a young investor is not only the opportunity to have more time investing in high-risk investments but also that much of the youth today have been exposed to technology from an early age. This differentiates the current youth greatly from their predecessors because they have had the adaptation of technology for most of their lives. In previous years, the number of American households with access to the internet was low.

However, as the years progress, there is more availability to explore the internet and market analysis. Making it easier to research how companies are operating and what corporations are predicted to grow in the coming years. This information is key to smart investing and gaining a profit on the share in a growing company.

Accessibility

Alongside technology comes accessibility to manage a portfolio. Portfolio maintenance is crucial, and technology allows for a constant “checkups” on how markets are doing and with current-day applications/software, there is a means to accomplish this. An investor is able to access all the information needed to buy a share by using any device with access to the internet unlike before where the method to acquire shares was via phone call, leaving the investor vulnerable to fraud.

Weaknesses

The second internal aspect is the weaknesses that the youth has when participating in self-directed investments. These

weaknesses are in the control of the young investor and can only be altered by the investor.

Individual Uncertainty

It is at the risk of the young individual to determine whether to enter the stock market. An internal weakness that many young investors will encounter is that with mobile stock trading, there is also the question of security with certain applications (Tai). In an earlier study conducted, it "identified this type of perceived risk as to the most important inhibitor to the adoption of mobile stock trading." This relates to the possibility of transaction interruptions, delays, or pausing when utilizing an online platform to trade and sell a stock. Depending on the individual's technology use, a technological interruption can cost the young investor a portion of their return/profit. Furthermore, the main issue with young investors is the lack of knowledge that can result in expensive consequences (Dasgupta 3). These outcomes may lead investors to feel discouraged and not be in the stock trading market for long.

Knowledge

As mentioned above, a fundamental issue that the youth face when attempting to expand their portfolio is the lack of knowledge (Dasgupta 3). Investing is not a topic taught at traditional high schools or colleges (reliant on the students' field of study). This weakness makes the student more prone to failure or mismanaging shares as opposed to someone who has been in the industry for a longer period of time. There is also little knowledge on the software created to help investors from the youth's perspective and the range of difficulty for a person to fully comprehend how the software operates varies from program to program. Although they are more welcoming of the use of technology, the experience is gained by using the software numerous times to trade and gain profits, which can only be accomplished with years of using the software system applications repeatedly.

Low Funding

Another main factor that is faced by young investors is the lack of funding or a principal amount of investment funds. When funds are lower, investors cancel their investments at a faster rate than those who have a larger pool of funding. This is because a loss hits those with low funding the hardest. Consequently, leading them to cancel investments rather than maintaining them in their portfolio because of fear of losing more capital. Low funding also places a limit on the number of shares or price of a share the investor can purchase. This may cause the investor to miss out on investment opportunities because he/she does not have enough resources to enter as a shareholder within a company.

Opportunities

The third component of the SWOT examination focuses on the external prospects of the youth investing in the stock market. Opportunities are out of the control of the investor.

Commission Free Applications

Along with the advancement of technology comes the creation of applications available to the youth's mobile devices that allow investing to be more accessible by cutting out the need for a broker and allows the individual to directly invest on their own. There is also a major issue solved when there is no brokerage fee. A fee discourages the youth to get involved with the stock market because it might require an amount that is not accessible to them at the time. With no minimum fee to enter the market, it opens up the door to investors who might have otherwise never gotten involved. It also gives the idea of "investor power" in which the individual investing feels free to buy the number shares he/she wants if they have the funding for it. This freedom is a major opportunity for the youth to get involved.

The Overall Trend of the Stock Market

In addition to the software available to young investors, the overall trend of the stock market is another major advantage. Getting involved in early investment is the potential to continually gain value on a share of a company. As most corporate trends demonstrate, although there are fluctuations, the overall trend of the stock market shows continual growth. The trend demonstrates that if the young investor persists with the share long enough it should ultimately be worth more in the future years than when first bought so there is the probability to gain a profit or at the minimum, recover what was invested.

Lower Market Values

In current times, because of the COVID-19 pandemic, company stock prices have dropped, and many investors are participating in the stock market. There is more opportunity for young investors since it will require less money to start investing in medium to large-sized corporations. Along with applications such as Robinhood, investors receive free stock when they sign up onto the program. Overall, low prices of stock allow the youth to have less opposition to starting their portfolio. In addition to this, there are also new startup companies looking for investors and since they require funding, they often drop their prices below the market value, which makes it an excellent opportunity for young investors to get involved.

Online Aid

Another great aspect of young investors having access to the internet is that there is much learning aid available to the youth. Apart from free financial analysis online, programs offer lessons to investors on how to properly invest and what to invest in. Some of these programs come with a price. However, the internet is home to numerous information outlets that can be accessed and used to research companies. These channels of information allow the investor to gain more knowledge faster than their predecessors.

Threats

The fourth part and final component of the SWOT examination focuses on the external risks faced by young investors who choose to involve themselves in the stock market. Threats are out of the control of the investor.

Cybersecurity/ Glitches

Along with the rise of technological innovation also comes the increase of technical issues such as cybersecurity. There is much information compiled in the stock market which makes it a target for hackers. Applications such as Robinhood have also experienced glitching with their software leading to panic among their users because of the inaccurate amount owed displayed on their accounts or inaccurate stock information.

Market Fluctuations

The market is constantly fluctuating making it an external threat to a new, young investor. In a study mentioned above, there was also a point made that with so many young individuals entering the stock exchange market, there will also be more competition that is created because of this (Dasgupta 3). This leads to lower selling prices due to an overflow of people attempting to enter a market, meaning investors will make a much smaller profit or even lose capital on the share. These market fluctuations are out of control for the investor and cause there to be a rise in panic due to the unpredicted and constantly changing future.

Inflation

Another obstacle faced by young investors that is out of their control is the inflation of the currency. In terms of the dollar, the annual inflation rate has continued to rise every year. This inflation rate indicates that the money that has been initially invested will depreciate alongside with the decreased value of the dollar. Unless the growth rate surpasses the inflation rate, there is a loss concealed as a gain. This is a major threat that corporations

are fully cognizant of. The deprivation of the value is also a factor that affects businesses thus impacting their stock value and their shareholders. Inflation is also something to consider when looking at companies to invest in, as inflation continues the amount of the dollar will continue to decrease and because of this, the revenues which companies are making will have to be adjusted for inflation along with all financial statements.

Constant Change of Consumer Preferences/ Competition

When it comes to investing, the youth examines companies that are performing well and have high chances of growth. However, these predictions often change within months. Stock trading is a massive marketplace with many parts to it, mostly comprised of competitors. This means that with consumer preferences constantly changing there will always be competitors attempting to penetrate a market. If a young investor buys shares of a certain company because he/she believes that there is potential gain, there are also other competing companies that may outshine the corporation making their stock price suffer. The high competition also results in a lower stock price due to the high saturation within any given market.

Better Regulation is Still Needed

In addition to the previous threats faced by young investors, there is also regulation that needs to be put into place by the entities running stock trading applications and software. Throughout the years, there have been numerous occasions in which software programs have caused inaccurate numbers to be shown in the user's account. This is an important issue because, with the COVID- 19 pandemic, more users have been involved with these stock exchange applications, making the odds of such glitches occurring to increase. Furthermore, regulation is needed to avoid any unnecessary stress on the individual that is a human response to financial loss. These losses are often caused as a result of system malfunctions. Such regulations include a cap or limit on the amount of the dollar amount an individual can invest

in. This ensures that the investor will be able to back up the dollar amount he/she plans to invest.

Conclusion

Through the literature and information gained throughout this study, it is beneficial for youth to involve in innovative self-directed investments with some limitations. Although commission-free software is new ground, there is much knowledge to gain as a young investor that leads up to a large portfolio as time progresses. In addition to this, in the technology aspect, the youth has more to gain. Technological advances allow there to be more information available when researching specific companies and stock prices. This allows the youth to make well-informed decisions before becoming a stakeholder. In this case, the benefits outweigh the cost. However, technology may also be an issue due to it being susceptible to glitches or hacking. That is why as time progresses, the outlook is that stock exchange systems realize this and work towards creating better regulations to help make stock trading safer for investors, specifically young investors. Previous generations had to go through numerous processes of researching and located a broker which was a hassle. With technology and the youth knowing how to properly adapt this technology in trading allows there to be more resources that direct them to potentially become successful sooner as opposed to their predecessors which would have taken them a longer time to decipher the information which is now available to the young investor at minimal to no cost.

References

- Arnott, R., & Wu, L. (2014). *What Are We Doing to Our Young Investors?* 3.
- Dasgupta, S. (1998). Electronic Contracting in Online Stock Trading. *Electronic Markets*, 8(3), 20– 22.
<https://doi.org/10.1080/10196789800000035>
- Hamilton, Myra, and Clive Hamilton. *Baby Boomers and Retirement*. p. 88.
- Harding, A., & Kelly, S. (2004). Funding the Retirement of the Baby Boomers. *Agenda - A Journal of Policy Analysis and Reform*, 11(2).
<https://doi.org/10.22459/AG.11.02.2004.01>
- Hill, T., & Westbrook, R. (1997). SWOT analysis: It's time for a product recall. *Long Range Planning*, 30(1), 46–52.
[https://doi.org/10.1016/S0024-6301\(96\)00095-7](https://doi.org/10.1016/S0024-6301(96)00095-7)
- Klebnikov, S. (2020, June 19). 20-Year-Old Robinhood Customer Dies By Suicide After Seeing A \$730,000 Negative Balance. Retrieved June 17, 2020, from
<https://www.forbes.com/sites/sergeiklebnikov/2020/06/17/20-year-old-robinhood-customer-dies-by-suicide-after-seeing-a-730000-negative-balance/>
- Lee, Jae Min, and Sherman D. Hanna. “Savings Goals and Saving Behavior From a Perspective of Maslow’s Hierarchy of Needs.” *Journal of Financial Counseling and Planning*, vol. 26, no. 2, Nov. 2015, pp. 129–47. DOI.org (Crossref), doi:10.1891/1052-3073.26.2.129.
- Mohamed, T. (2019, November 13). Robinhood's 'infinite money' glitch shows the dangers of turning investing into a game, expert says | Markets Insider. Retrieved June 17, 2020, from
<https://markets.businessinsider.com/news/stocks/robinhood-investing-infinite-money-leverage-glitch-shows-risk-investing-game-2019-11-1028685860>

- Morrison, M. (2019, August 02). The Complete History and Guide to SWOT Analysis. Retrieved June 02, 2020, from <https://rapidbi.com/swotanalysis/>
- Redrow, Gina Marie. *An Analysis of the Design, Implementation and Measurement of a 401K Employee Communication Campaign for Checkpoint Systems, Inc. Headquarters Employees to Evaluate Their Understanding of the Plan.* p. 39.
- Schooley, S. (2019, June 23). SWOT Analysis: Definition and Examples. Retrieved June 03, 2020, from <https://www.businessnewsdaily.com/4245-swot-analysis.html>
- Stawski, Robert S., et al. “Goal Clarity and Financial Planning Activities as Determinants of Retirement Savings Contributions.” *The International Journal of Aging and Human Development*, vol. 64, no. 1, Jan. 2007, pp. 13–32. SAGE Journals, doi:10.2190/13GK-5H72-H324-16P2.
- Tai, Y.-M., & Ku, Y.-C. (2013). *Will stock investors use mobile stock trading? A benefit-risk assessment based on a modified UTAUT model.* *14*(1), 18.
- Thakur, S. (2010, December 16). SWOT – History and Evolution. Retrieved June 01, 2020, from <https://www.brightbpm.com/methods-strategies/99629-history-of-the-swot-analysis/>
- What’s swot in strategic analysis? (1998). *Strategic Change*, 9.
- Whitelaw, R. F. (2000). Stock Market Risk and Return: An Equilibrium Approach. *The Review of Financial Studies*, *13*(3), 521–547. JSTOR.

Identifying Effective Drug Treatments of Receptor Tyrosine Kinase Targeted Inhibition in Ewing's Sarcoma and Rhabdomyosarcoma

Elysandra Solis

Mentor: Terry Jo Shackelford, Ph.D.
St. Mary's University, San Antonio, TX

Treatment of pediatric sarcomas has in recent years captivated researchers to combat these rare diseases through in vitro studies that would then be evaluated for clinical trials. The importance of these in vitro studies stems from the rarity of these cancers, with diagnosis being low and prognosis being poor the importance of these in vitro studies is heightened to allow for a thorough prediction of how inhibitors will affect the targeted cancer cells, which would allow for a clinical trial to take place. The sarcomas focused on in this paper are Ewing's Sarcoma and Rhabdomyosarcoma, both of which are pediatric sarcomas that respectively affect the bone and soft tissue of its host. The Ewing Sarcoma cell lines were treated with BRD4, CDK4/6 and FGFR inhibitors and all displayed an acceptable inhibition at concentrations of 100-1000 nM. Focusing on the results of the most influential gene, it was inferred that CDK4 and sister gene FRS2 should be observed for future in vitro work and further clinical trials. As for the Rhabdomyosarcoma cell lines observed, which were RD, RH30, RH41, RH36, three different inhibitors were used alone and with the IGF-1R inhibitor TZ1 to observe the effect the addition of TZ1 would have on cell survival. The pronounced effect was observed through comparison of IC₅₀ values with and without the TZ1. Understanding the effects these inhibitors have on these various cell lines will allow for implementation of clinical trials that could eventually improve the vitality of patients with Rhabdomyosarcoma and Ewing's Sarcoma.

Introduction

The purpose of this paper is to analyze two adolescent sarcomas and present the results of testing different drug treatments, to better treat Ewing's sarcoma (EWS) and Rhabdomyosarcoma (RMS) patients. EWS is a type of cancer that can arise in bone or soft tissues and is characterized by a recurrent chromosomal translocation resulting in the fusion of the EWS gene on chromosome 22 with one of several genes of the EWS family of tumors.¹ The occurrence of EWS between 1973 and 2004 was approximately 2.93 per 1,000,000 individuals, and has been found to be more common in white populations, with a slight male predominance.² Another type of childhood sarcoma is Rhabdomyosarcoma (RMS), the most common soft tissue sarcoma that stems from developing cells that form striated muscle.³ The annual incidence of RMS is estimated at 4.5 cases per 1,000,000 children, with approximately 50% of cases being diagnosed in the first decade of life.⁴

The main aspect that EWS and RMS share is their reliance on receptor tyrosine kinases (RTKs) to allow for the continued cell division and accumulation of cancer cells. Currently there are a number of different treatments such as chemotherapy, radiation therapy, surgical resection and various inhibitors being developed to treat EWS and RMS.⁵ Many of the inhibitors being developed and put into trials that are aimed at disrupting RTKs. With the success of the inhibition of RTKs in other cancers, many drugs have been produced for these two sarcomas that are aimed at disrupting the RTK signaling to allot for the best results of remission, survival and minimal drug consequences.

Most current drug treatments consist of inhibition of the insulin-like growth factor (IGF) pathway, with a combination drug to inhibit another aspect of EWS. These combinatorial drugs range from inhibition of epidermal growth factor receptor (EGFR) with IGF-1R to inhibition of mTOR with IGF-1R, all with variant results in their success.⁶ One combination treatment observed is an IGF-1R antibody and rapamycin, which indirectly

inhibits the mTOR pathway, the combination had an increased inhibition versus either drug alone. These results demonstrate a route to overcome mTOR inhibition resistance which occurs with the use of rapamycin alone.⁶ Considering that mTOR is downstream from RTK signaling, it is logical to inhibit the pathway at two points, the beginning of the RTK signaling with the IGF-1R inhibitor and later in the pathway with rapamycin to combat diversion of signaling to avoid inhibition. Another combination treatment is the use of an EGFR inhibitor with an IGF-1R inhibitor to promote the effects of EGFR inhibition and delay resistance by the use of IGF-1R inhibition.¹¹ Though these results demonstrate progress in the search for a cure of Ewing's Sarcoma and Rhabdomyosarcoma, the rarity of diagnoses with these types of cancers does not allot for the numerous amounts of clinical trials as per se breast cancer. Due to this fact, it is pertinent that thorough research be done in vitro to ensure the same prospects for clinical trials, which is our goal in this paper.

The pathway in which RTK activation functions, is edited in cancers, to illustrate the differences it is important to understand both editions. Firstly, under normal physiological conditions RTK activation occurs by receptor-specific ligands, which can lead to different pathway journeys, including one that leads to a conformational change that allows the tyrosine kinase domain (TKD) to be *trans*-autophosphorylated.¹² *Trans*-autophosphorylation differs from *cis*-autophosphorylation in the specific way the phosphorylation occurs; *trans*- occurs by intermolecular means, meaning that another protein of the same type provides the active site to catalyze phosphorylation, *cis*-occurs by intramolecular means, meaning the active site of the kinase catalyzes its own phosphorylation.²⁰ This catalysis allows for the activation of downstream pathways like PI3K/Akt, where PI3K activation promotes cancer cell growth, survival, and metabolism, along with the activation of Akt.¹¹ Activation of these type of pathways begins the journey of the activated protein which will arrive in the nucleus and code for the increased transcription of their respective genes. The ability of the TKD to

be *trans*-autophosphorylated. allows for the release of a *cis*-autoinhibition, which in FGFR and IGF-1R receptors allows for the cease of disruption of ATP and substrate binding.¹² In cancer, there are four dogmatic pathways in which RTK over activation occurs: gain-of-function mutations, genomic amplification, chromosomal rearrangements, and autocrine activation.¹² These different pathways have one commonality, their complexity and disorganization. Although the mechanisms in which oncogenic RTK activation are known, they are simply an outline of the main function cancer cells, to survive at all costs.

In Ewing's sarcoma there are many different pathways that consist of a variety of RTKs and their regulatory proteins. The different pathways we focus on in this paper focus on these proteins, fibroblast growth factor (FGFR), bromodomain-containing protein 4 (BRD4) and cyclin-dependent kinase 4/6 (CDK-4/6). The purpose of these proteins vary, from cell growth and survival to cell cycle progression to regulation of angiogenesis to regulation of RTKs. the FGFR pathway which plays an imperative role in the regulation of cell growth, cell production, cell differentiation, cell survival, and angiogenesis.⁷ Firstly, the bind of FGFs to FGFRs occur and stimulate receptor dimerization which in turn leads to the activation of the bound FGFRs.⁷ Activation of these FGFRs, enables the intracellular kinases to be in a close enough vicinity that they can transphosphorylate one another.⁷ This transphosphorylation allows for the cataract of downstream signals to be initiated, with an end effect on mitogenesis and differentiation. With the acknowledgement of the functions of FGFR, it is predicted that the use of LY2874455, an FGFR inhibitor will produce an acceptable inhibition of Ewing Sarcoma cell lines ES1, ES2, ES3, ES4, ES6, EW8 and TC71.

The next pathway to be discussed is the bromodomain-containing protein 4, which plays a key role in the regulation of RTKs. BRD4 belongs to the Bromodomain and Extra-Terminal Domain (BET) family of proteins, known for their importance as readers for acetylated histones.⁸ Histone acetylation is the process

in which an acetyl group is added to the N-terminus of a lysine residue on a histone. Through research into the relationship between the BET family and EWS, it has been found that the inhibition of BET proteins selectively targets expression of a subset of genes that are upregulated by EWS-FLI1, which drives chromosomal translocations in EWS.⁸ This finding displays the relationship between BET and EWS as one of indirect transcriptional impact, meaning that along the pathway of EWS there is a point at which the pathway of the proteins of the BET family intersect, inadvertently affecting transcription. The importance of BET proteins as a target gene is easily known in its relationship with EWS, but also its alternative approach to block the IGF1 pathway without adverse effects to the growth of the patient. Overall findings in the research led to the conclusion that the communication between BET proteins and EWS-FLI1 is potentially mediated via adjacent histone acetylation marks and enhancer activities.⁸ Recognizing that due to their relationship, the inhibition of the BET family of proteins should indirectly inhibit the transcription of EWS-FLI1 target genes.⁸ This prediction is tested in this paper on varying EWS cell lines, to better understand the specific target genes BET/BRD4 inhibition will impact.

The last pathway to be discussed is the cyclin-dependent kinase 4/6, CDKs are serine/threonine kinases involved in cell cycle progression and transcription.⁹ When fueled, CDK 4/6 phosphorylates different sites in the retinoblastoma (RB1) tumor suppressor protein into a hyperphosphorylated, which in turn encourages cell cycle advancement.⁹ The ability to promote the cell cycle occurs by requisitioning E2F transcription factors, which transcribe the genes necessary for the DNA replication portion of the cell cycle. Understanding the mechanisms of which CDK 4/6 works and its occurrence of alteration in sarcomas to continuously go through the cell cycle, allots for the prediction that inhibition of this altered kinase by LY2813345 shall result in the halt of continuous cell cycle progression to a more normalized state.

It is assumed that the inhibitors will have the same effect on RMS cells as they do on EWS cells, shown in Figure 1 (RMS) and Figure 2 (EWS). These figures depict the known pathways of these two sarcomas, including target genes, kinases, and phosphatases.^{17,18} With that assumption in mind, the true analysis for RMS cells is on combinational impact with IGFR inhibitor TZ1 being the second-half of the combination. By acknowledging what is known about these target genes and the effect the inhibitor is presumed to have, it can be assumed that the results of these hypotheses will allow the passing of one more mile marker in the race to find the best treatment for these two sarcomas.

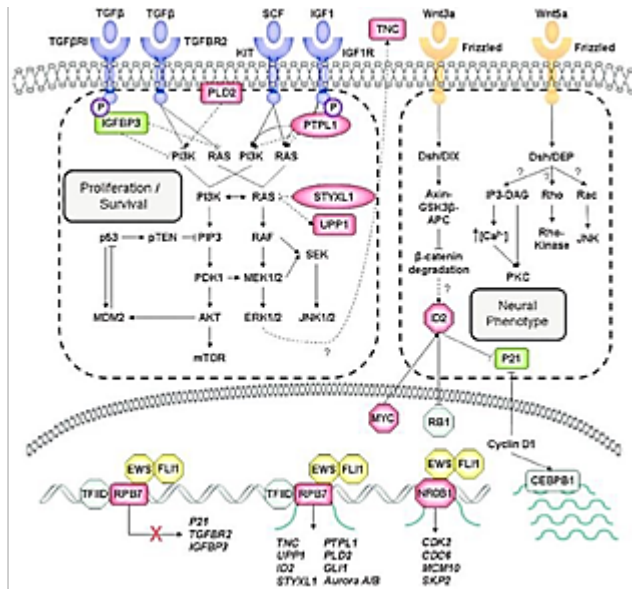


Figure 1. Ewing’s Sarcoma signaling pathways. Dashed lines represent signaling pathways involved in ES proliferation-survival and phenotype, continuous lines represent canonical pathways, red means upregulation, and green means downregulation. While EWS/FLI1 targets are represented by boxes, kinases are hexagons, phosphatases are ovals, transcription factors are octagons and other targets are rectangles.

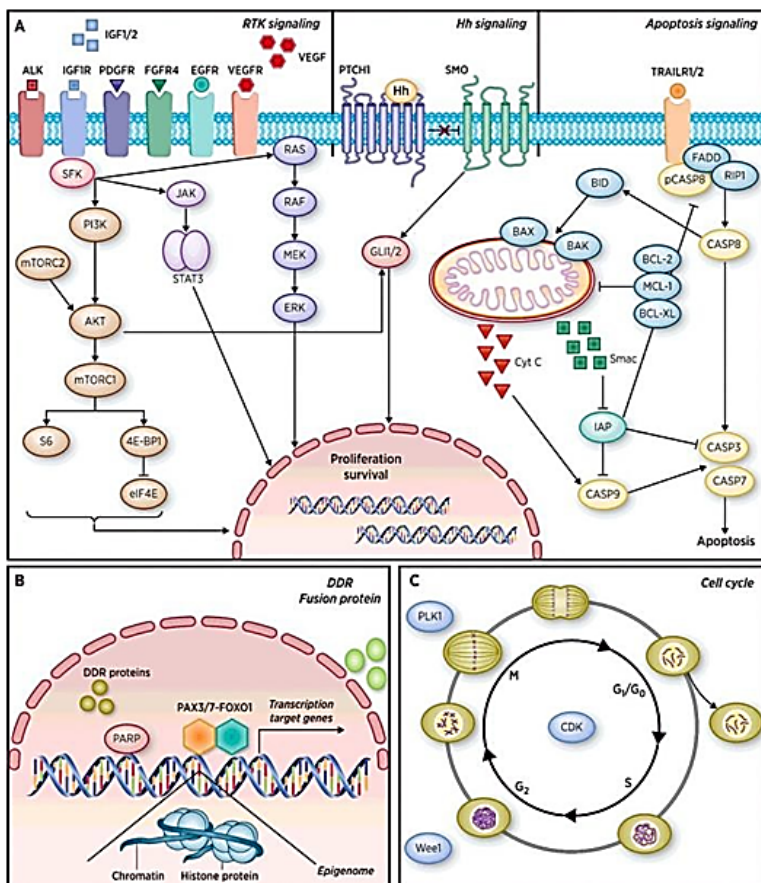


Figure 2. Overview of Rhabdomyosarcoma pathways, including the various RTK signaling pathways (A), its cell cycle (B), and the DNA damage response pathway

MATERIALS AND METHODS

Cell Lines and Cell Culture

The RMS (RD, Rh30, Rh36, and Rh41) and EWS (ES1, ES2, ES3, ES4, ES6, EW8 and TC71) cell lines were tested for sensitivity to the inhibitor TZ1. To ensure the quality of the cells, routine short tandem repeat assays were conducted, and compared to the original short tandem repeat profile established on early passage lines and stored in a Master Bank. All cell lines were preserved in a 37°C environment with 5% CO₂ in an antibiotic-

free RPMI high glucose supplemented growth medium otherwise known as Invitrogen with 10% FBS obtained from Sigma-Aldrich and 2 mM glutamine. To obtain a resistant cell line, Rh41 cells were subjected to TZ1 at half of its IC₅₀ concentration, which was increased with every passage until viability of the resistant cells was achieved at 10µM of the drug.¹⁹

Cell Viability Assay

The performed cell viability assays allowed *for the determination of the concentration at which 50% of cell survival would be inhibited by the treatment otherwise known as the IC₅₀ concentration.* This was achieved by seeding the cells into 96-well plates with a density of 2.5×10^3 cells per well and were left overnight. The next day, the cells were treated with their respective inhibitor at an increased concentration, continuing an incremental increase until the fourth day. After the fourth day, cell viability was measured with Alamar blue by pouring the reagents directly into the culture medium quantifying a final concentration of 10% v/v. The cells were incubated once again for 4 hours and fluorescence was taken with excitation at 530nm and emission at 590nm. To produce negative controls for more accurate comparison, Alamar blue was added directly to medium without cells. Observed results were expressed with mean viable cells compared to cells treated with DMSO alone \pm SD. Combination studies were performed for RMS cells with the same protocols, having the results expressed as mean viable cells compared to results of the fixed drug alone viewed as 100% cell viability. All assays were done in triplicate and repeated tree times.¹⁹

Statistics

Using GraphPad Prism, analysis of the data gathered was performed. The IC₅₀ values were first transformed into the log of themselves and then the drug concentrations, producing graphs comparing the log of the drug concentration to the log of the IC₅₀ values for each cell line. Analysis of the IC₅₀ values gathered

from the graphs of all cell lines for each inhibitor was entered into a spreadsheet and graphed representing the value at which IC₅₀ occurred. The same analysis was repeated for the RMS cell lines.

cBioPortal

The cBioPortal website was accessed at <https://www.cbioportal.org> and five studies were selected, Pediatric Preclinical Testing Consortium, Pediatric Ewing Sarcoma, Ewing Sarcoma, Sarcoma, Sarcoma and Rhabdomyosarcoma.^{13,14} From these five studies, seven genes were selected to be analyzed for alterations: BRD4, CDK4, CDK6, FGFR1, FGFR2, FGFR3, and FGFR4. The overall survival graph and copy-number alteration frequency graph were analyzed. From there the graphs for the expression of CDK4 and FRS2 were analyzed, with the mutation map for both genes.

RESULTS

The studies performed on the 7 cell lines of EWS and 4 cell lines of RMS, allowed for further study of the effects these inhibitors have on these sarcoma cell lines. Understanding these effects allows for the eventual development of clinical trials that if successful would lead to better prospects for children with these sarcomas. Firstly, we analyzed the EWS cell lines and the effects the various inhibitors had on them, granting insight into the function of the target genes in EWS.

Upon analysis of the data presented in Figure 3 it was discovered that between the four inhibitors and their target genes, CDK4 achieved 50% inhibition of cell growth with the least drug concentration. The FGFR inhibitor had two varying reactions based on the company it was made at, the LY2874455 created by Eli Lilly proved to achieve IC₅₀ at approximately 500nM, whereas the Selleck version achieved IC₅₀ at approximately 1000nM.

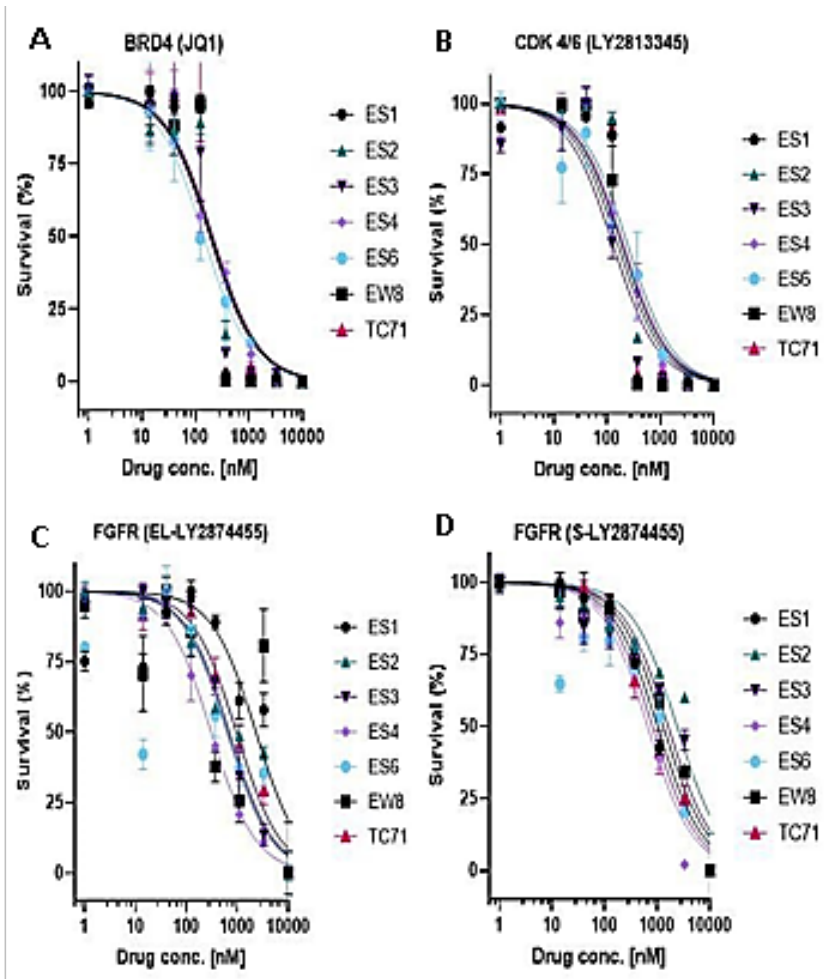


Figure 3. The relationship between cell survival and drug concentrations for each cell line, allowing for the comparison between the different inhibitors and their respective target gene: A) JQ1, B) LY2813345, C) EL- LY874455, D) S- LY2874455

The IC₅₀ graphs shown in Figure 4, display the correlation between when 50% inhibition was achieved for each cell line with the varying inhibitors. It is shown that CDK 4/6 inhibitor,

LY2813345 achieved IC₅₀ at lower values for each cell line, providing the best results at the lowest drug concentration.

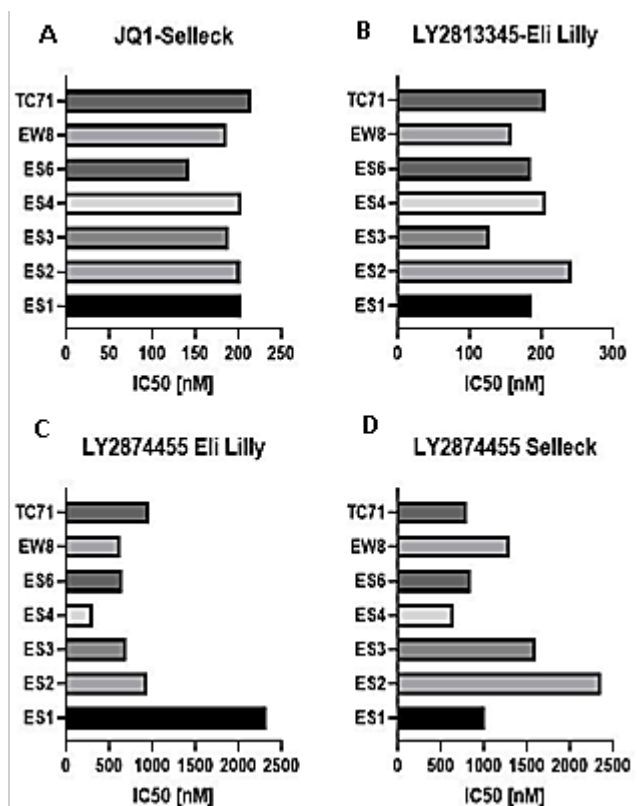


Figure 4. The levels of which inhibition of 50% of cell survival was achieved for each cell line using the respective drug for each target gene. A) JQ1, B) LY2813345, C) EL- LY874455, D) S- LY2874455

Acknowledging the importance of this research given the poor prognosis given, statistical evidence was gathered from c-BioPortal to understand the effect these target genes have on patient survival. c-BioPortal is an interactive site, housing the data from a variety of cancer studies that allow researchers to create and analyze their own genetic studies from an immense library of cancer data. In this case, c-BioPortal was used to gather

more data on the set of genes focused on in this paper: BRD4, CDK4, CDK6, and FGFR 1-4. The occurrence of these targeted genes decreases overall survival of patients by approximately 16%, displaying the significance these genes have in patient survival (Figure 5). The altered group consists of samples taken that show some alteration/mutation in one or multiple genes in the focused gene set (BRD4, CDK4, CDK6, and FGFR 1-4), while the unaltered group consists solely of samples without alterations in the focused gene set. According to the data, at 10 years the survival rate for the unaltered group was 49.26%, while the altered group measured at 33.58% (Figure 5). This data suggests that changes in any one or multiple genes in this set identifies a group of patients that has a 15.62% worse survival rate and really sets this group apart supporting the idea that these genes are contributing to the tumorigenesis process.

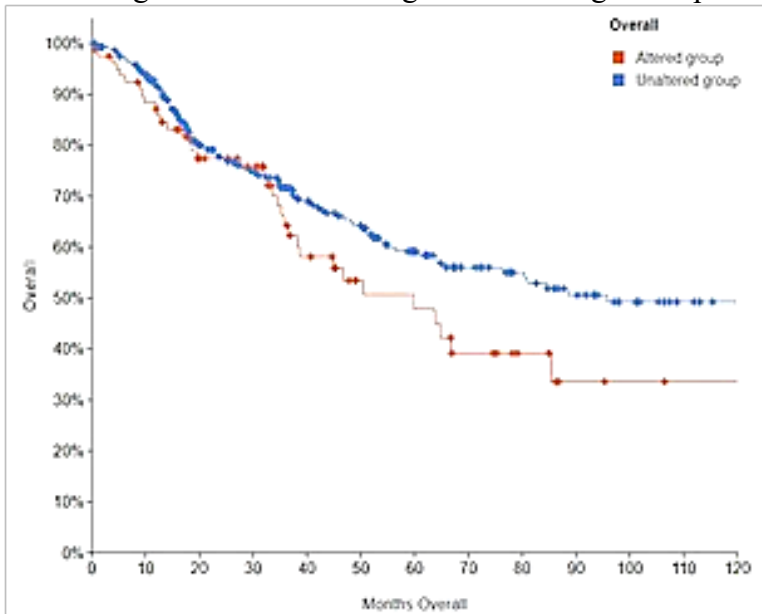


Figure 5. Overall survival of a group with altered BRD4, CDK4, CDK6, FGFR1, FGFR2, FGFR3, and/or FGFR4 genes compared to a group without these altered genes.

With an understanding of the effect these targeted genes have on patient survival it was determined that further study needed to be conducted. This was done by determining other gene alterations that occur alongside the alterations by BRD4, CDK4, CDK6, and FGFR1-4, as shown in Figure 6. In this case altered means that the gene is not part of the focused gene set but is mutated at the same time the focused gene set is mutated. The alteration frequency details how many times these mutations occur in these genes mutated alongside the focused gene set. The genes shown in Figure 6 range from tumor promoters like MDM2, cell cycle regulators like TSPAN31, and actin regulatory proteins like AVIL.

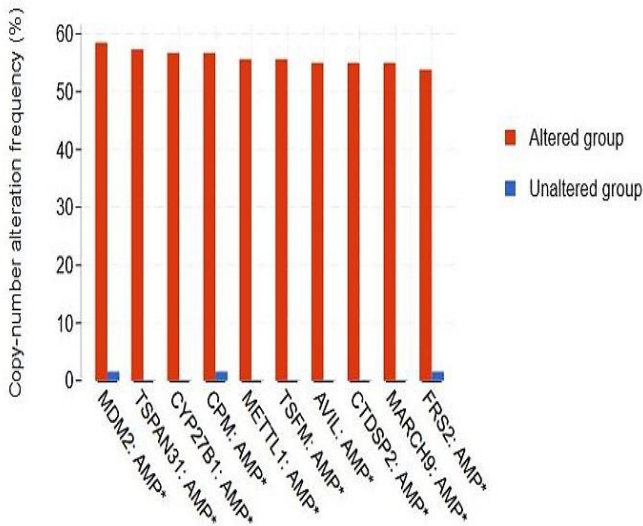


Figure 6. Display of other gene copy-number alteration frequencies that occur in the chosen altered group consisting of genes with alterations in BRD4, CDK4, CDK6, FGFR1, FGFR2, FGFR3, and/or FGFR4

The successful inhibition of CDK 4 at a low drug concentration and the impact these gene alterations have on overall survival allowed for the conclusion that CDK4 has a significant impact on EWS. Therefore, to understand how much

significance CDK4 has in EWS, further analysis was done and compared to another unrelated, altered gene that occurs at a frequency of 55%, known as FRS2. FRS2 stands for Fibroblast Growth Factor Receptor Substrate 2, which functions as a protein coding gene and is associated with Rete Testis Adenoma and Liposarcoma. There is a clear depiction of the RNA expression for CDK4 and FRS2, with detailed analysis of the type of mutations that occurs within both genes (Figure 7). Understanding that expression in sarcoma cells was increased in CDK4 by 10-18 fold and FRS2 by 8-14 fold than in normal cells (Figure 7). Analysis of this data, led to the understanding of the correlation between the increase of RNA expression and all gene alterations. The red shown in Figure 5 represents an amplification mutation and correlates with the highest levels of RNA expression with CDK4 from 13-18 and FRS2 from 9-14

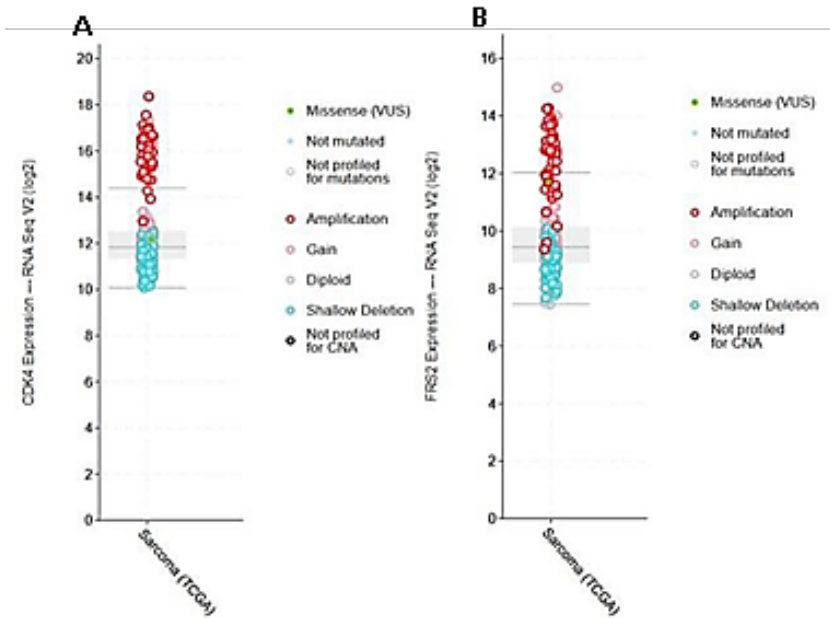


Figure 7. Expression comparison of CDK4 (A) and FRS2 (B), showing an amplification mutation that produces a 14-fold difference in CDK4 and a 12-fold difference in FRS2 compared to normal cells.

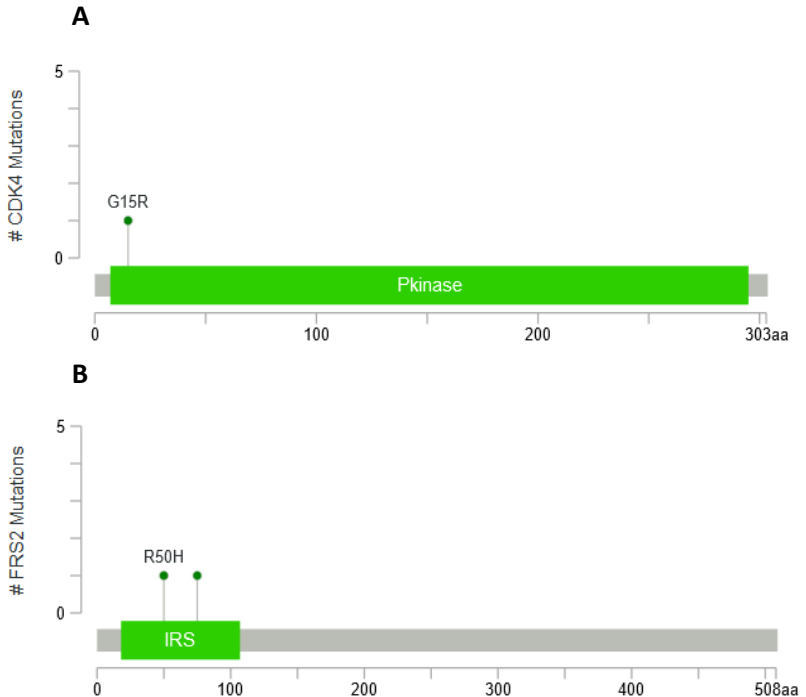


Figure 8. Mutation mapping for CDK4 (A) and FRS2 (B) mutations, detailing which amino acid the mutation takes place and the section of the protein that mutation occurs in.

For increased understanding of the mutations that occur in both CDK4 and FRS2, mutation mapping for each gene was analyzed, with CDK4 showing one mutation hot spot and FRS2 showing two. The mutation hotspot is noted with the lollipop figurine to indicate that this mutation has been noted in sarcomas quite consistently. The only lollipop figurine seen in the CDK4 mutation mapping (Figure 8A) is housed in the Protein Kinase Domain of CDK4 which spans from codon 7-295. G15R seen in the CDK4 map represents a missense mutation at the 15th codon where the codon was changed from a G to an R. This missense mutation is suspected by PolyPhen-2 and SIFT, two software's incorporated into c-BioPortal to be deleterious. In the FRS2 mapping, both lollipop figurines are housed in the phosphotyrosine-binding domain of insulin receptor substrate-1 in FRS2 which ranges

from codon 18-107. The first lollipop figurine represents a missense mutation of the 50th codon being changed from an R to an H, which is believed to have a benign impact on the gene (Figure 8B). The second lollipop figurine details a missense mutation at the 75th codon changing it to a K from an E, which is believed to have a deleterious impact on FRS2 leading to a copy-number amplification.

We further investigated inhibitors of these pathways in RMS cells to determine if they would act similarly to the EWS cells. Similar graphs to Figure 1 were constructed with four different cell lines: RD, Rh30, Rh36, and Rh41.

With an understanding of how the inhibitors tested in EWS cells works, it was inferred that they would work in a similar manner for RMS cells. Keeping this idea in mind, the differences in reaction to not only JQ1, LY2813345, and LY2874455 were observed but also the combinational reaction with IGFR inhibitor TZ1. The first comparison analyzed was BRD4 inhibitor JQ1 which was only tested for RD, Rh30, and Rh41. This analysis showed that JQ1 alone had a significant lack of inhibition, given the IC₅₀ value but with TZ1 the trend changed drastically for cell line Rh41 which achieved IC₅₀ at roughly 10nM (Figure9C). Cell lines RD and Rh30 also achieved IC₅₀ values at lower drug concentrations of 5000nM and 1000nM, respectively (Figure 9 A & B).

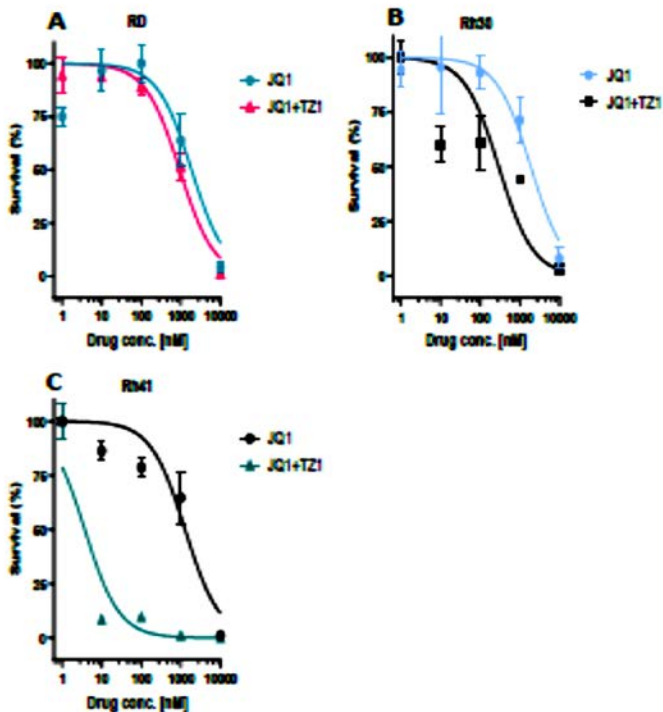


Figure 9. Comparison of the inhibitory effects of BRD4 inhibitor JQ1 on RMS cell lines with and without IGFR inhibitor TZ1. A) RD, B) Rh30, C) Rh41

A similar occurrence was observed in the comparison of CDK 4/6 inhibitor LY2813345 with and without TZ1 (Figure 10). Initially, all cell lines reached IC_{50} at 10,000nM or not at all. With an exception of Rh36 which achieved 50% inhibition at around 1000nM (Figure 10B). When TZ1 was added, all cell lines had an accounted drug concentration at which IC_{50} was reached; Rh36 at 100nM, Rh41 at 8nM, Rh30 at 50nM and RD at 5000nM (Figure 10).

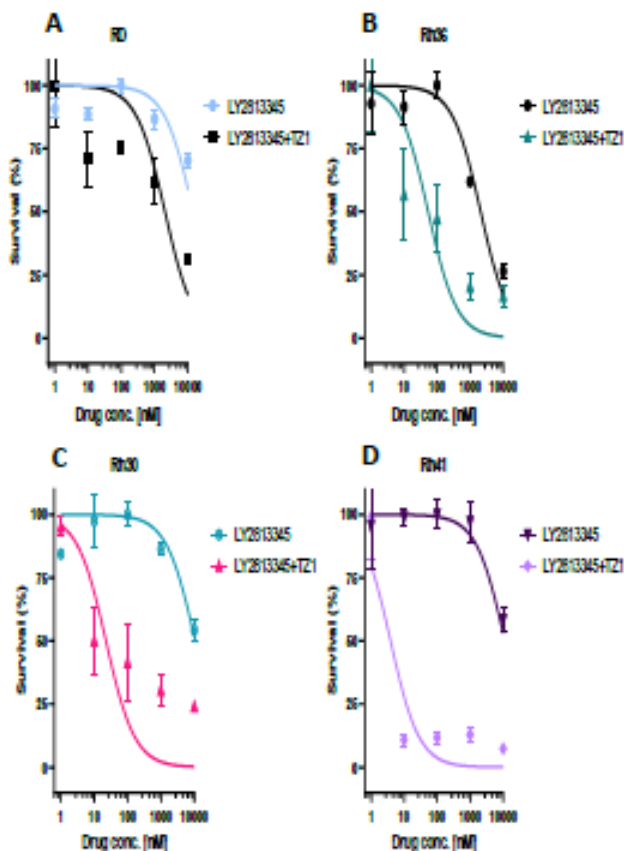


Figure 10. Comparison of the inhibitory effects of CDK4/6 inhibitor LY2813345 on RMS cell lines with and without IGFR inhibitor TZ1. A) RD, B) Rh36, C) Rh30, D) Rh41

The same trend was not observed for FGFR inhibitor LY2874455, which had initial IC₅₀ drug concentrations spread across the graph. For RD and Rh36 the IC₅₀ drug concentration changed minimally, if at all (Figure 11 A & B). On the other hand, the drug concentration at which IC₅₀ was achieved for cell line Rh41 showed a decrease of about 90nM (Figure 11C). While the IC₅₀ drug concentration for Rh30 decreased almost 200nM, the biggest change noted with FGFR inhibitor LY2874455 and IGFR inhibitor TZ1 (Figure 11D). The lack of change

shown with the combinatorial treatment LY2874455 and TZ1, provides evidence for the inference that targeting two growth factors at once results in minimal change, unlike in Figure 9 and 10.

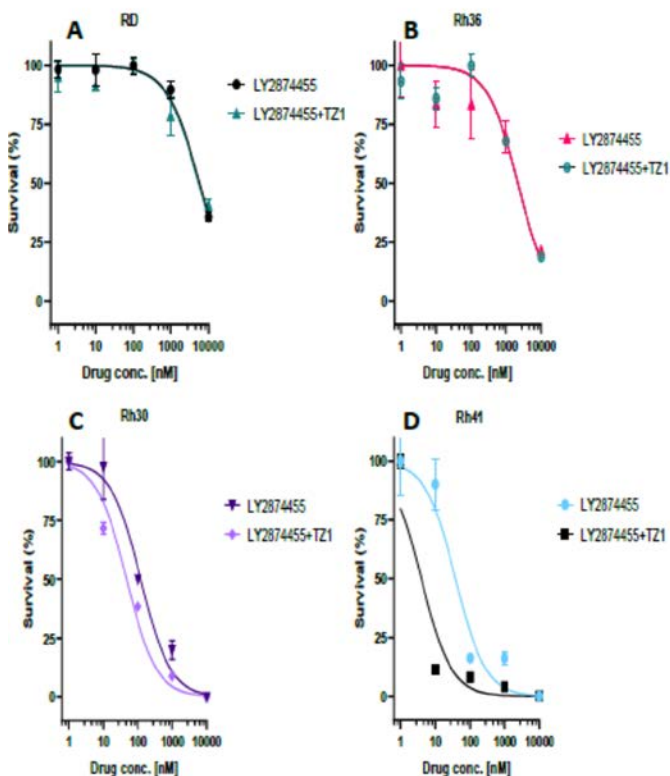


Figure 11. Comparison of the inhibitory effects of FGFR inhibitor LY2874455 on RMS cell lines with and without IGFR inhibitor TZ1. A) RD, B) Rh36, C) Rh30 D) Rh41

DISCUSSION

The determination of the functions of these target genes in these two sarcomas allowed for a gained insight into what the next step in fighting EWS and RMS should be. Acknowledging the significant role that CDK4 has not only in breast cancer but also in sarcoma patient survival as shown in Figure 3 and its achievement of IC_{50} at a lower drug concentration (Figure 4 & 10), will lead to future work in CDK4 inhibition. This future work will focus on the combinatorial aspects of

CDK4 with several other inhibitors, possibly an IGFR inhibitor, an FGFR inhibitor or an FRS2 inhibitor. As for the RMS cells, it is clear that to effectively inhibit cell growth the best tactic is to do combinatorial treatment with IGFR inhibitor TZ1. However, for FGFR inhibition the strategy does not apply, meaning that the best advice for future work is to trial other combinational treatments with other receptors that do not function as growth factors, considering that the combination of FGFR inhibitor and IGFR inhibitor did not perform as expected (Figure 11).

Overall, the knowledge accumulated by performing these analyses has led to substantial strides in the understanding of BRD4, CDK4/6, and FGFR, their inhibition and their significance in Ewing's Sarcoma and Rhabdomyosarcoma. However, there are still future endeavors that must be embarked on to obtain a more detailed of CDK4 and its interaction in these sarcomas, as well as the reasoning behind the poor results of FGFR and IGFR inhibition. Until more information can be known about the aspects of these genes and how their inhibition will affect sarcoma patients in clinical trials.

ACKNOWLEDGEMENTS

I would like to acknowledge my mentor Dr. Terry Jo Shackelford for the opportunity to do research with her and the St. Mary's McNair Scholars Program for making this all possible.

REFERENCES

1. Rikhsaf, Bart, et al. "The Insulin-like Growth Factor System and Sarcomas." *The Journal of Pathology*, vol. 217, no. 4, 2009, pp. 469–82. Wiley Online Library, doi:10.1002/path.2499.
2. Balamuth, Naomi J., and Richard B. Womer. "Ewing's Sarcoma." *The Lancet Oncology*, vol. 11, no. 2, Feb. 2010, pp. 184–92. ScienceDirect, doi:10.1016/S1470-2045(09)70286-4.
3. Kim, Su Young, Jeffrey A. Toretsky, et al. "The Role of IGF-1R in Pediatric Malignancies." *The Oncologist*, vol. 14, no. 1, Jan. 2009, pp. 83–91. PubMed, doi:10.1634/theoncologist.2008-0189.
4. Shern, Jack F., et al. "Pediatric Rhabdomyosarcoma." *Critical Reviews in Oncogenesis*, vol. 20, no. 3–4, 2015, pp. 227–43.
5. Yohe, Marielle E., et al. "Insights into Pediatric Rhabdomyosarcoma Research: Challenges and Goals." *Pediatric Blood*

& Cancer, vol. 66, no. 10, 2019, p. e27869. Wiley Online Library, doi:10.1002/psc.27869.

6. Kim, Su Young, Xiaolin Wan, et al. "Targeting IGF- 1R in the Treatment of Sarcomas: Past, Present and Future." *Bulletin Du Cancer*, vol. 96, no. 7, July 2009, pp.E52–60. DOI.org (Crossref), doi:10.1684/bdc.2009.0915.

7. Zhou, Wen-Ya, et al. "Characterization of FGFR Signaling Pathway as Therapeutic Targets for Sarcoma Patients." *Cancer Biology & Medicine*, vol. 13, no. 2, 2016, pp. 260–68. DOI.org (Crossref), doi:10.20892/j.issn.2095-3941.2015.0102.

8. Loganathan, Sudan N., et al. "BET Bromodomain Inhibitors Suppress EWS-FLI1-Dependent Transcription and the IGF1 Autocrine Mechanism in Ewing Sarcoma." *Oncotarget*, vol. 7, no. 28, July 2016, pp. 43504–17. DOI.org (Crossref), doi:10.18632/oncotarget.9762.

9. Kohlmeyer, Jordan L., et al. "CDKs in Sarcoma: Mediators of Disease and Emerging Therapeutic Targets." *International Journal of Molecular Sciences*, vol. 21, no. 8, Apr. 2020, p. 3018. DOI.org (Crossref), doi:10.3390/ijms21083018.

10. Selleck Chemicals. [(accessed on 17 June 2020)]; Available online: <https://www.selleckchem.com>

11. Engelman, Jeffrey A. "Targeting PI3K Signalling in Cancer: Opportunities, Challenges and Limitations." *Nature Reviews Cancer*, vol. 9, no. 8, 8, Nature Publishing Group, Aug. 2009, pp. 550–62. www-nature-com.libproxy.uthscsa.edu, doi:10.1038/nrc2664.

12. Du, Zhenfang, and Christine M. Lovly. "Mechanisms of Receptor Tyrosine Kinase Activation in Cancer." *Molecular Cancer*, vol. 17, Feb. 2018. PubMed Central, doi:10.1186/s12943-018-0782-4.

13. Cerami et al. The cBio Cancer Genomics Portal: An Open Platform for Exploring Multidimensional Cancer Genomics Data. *Cancer Discovery*. May 2012 2; 401. PubMed.

14. Gao et al. Integrative analysis of complex cancer genomics and clinical profiles using the cBioPortal. *Sci. Signal*. 6, pl1 (2013). PubMed.

15. Shackelford, Terry J, et al. "Intrinsic and Acquired Resistance to Antibodies Targeting the Type-I Insulin- like Growth Factor Receptor in Cells Derived from Childhood Sarcoma." Submitted.

16. Casino, Patricia, et al. "Visualizing Autophosphorylation in Histidine Kinases." *Nature Communications*, vol. 5, no. 1, May 2014, p. 3258. DOI.org (Crossref), doi:10.1038/ncomms4258.

17. Mackintosh, Carlos & Madoz-Gúrpide, Juan & Ordóñez, Jose & Osuna, Daniel & Herrero-Martín, David. (2010). The molecular pathogenesis of Ewing sarcoma. *Cancer biology & therapy*. 9. 655-67. 10.4161/cbt.9.9.11511.
18. van Erp, Anke E. M., et al. "Targeted Therapy-Based Combination Treatment in Rhabdomyosarcoma." *Molecular Cancer Therapeutics*, vol. 17, no. 7, July 2018, p. 1365, doi:10.1158/1535-7163.MCT-17-1131

Identifying Failure Points of Steam Traps Using Machine Learning

Gissella Lara

Mentor: Juan D. Ocampo, Ph.D.

St. Mary's University, San Antonio, TX

In the modern world, the increasing energy demand requires more efficient methods of producing and processing such energy. In power plants, 47% of the energy created is lost through the processing methods being employed. Such loss in energy can never be recovered. Steam Traps is one method to increase the efficiency of a plant while reducing the risk posed by condensation of the vapor passing through the system. Over time, such steam traps can experience wear and begin to cause a loss of efficiency by allowing steam to escape through a loose or defective valve. As a steam trap malfunction may not be easy to detect and many plants do not implement steam trap maintenance, the trap could effectively stay in service much longer than its service life allows. This project focuses on the creation of a device that, using machine learning, will be able to diagnose faulty steam traps thereby eliminating the need of a specialized technician. Through the use of sound and computer software, engineers will be able to detect failure points in steam traps and maintain them in service for longer periods of time with no major repairs.

Keywords: Steam Traps, sound, failure points, MatLab

Introduction

Manufacturing and power plants have become the source of making so much equipment, resources, and luxuries that many people hold valuable. With most of these objects or resources that are made and needed, such as power for one's home or a car, an intricate process is involved behind the doors of the plants. A part of the long development process involves steam traps. Steam traps are a type of automatic valve that filters out condensate and non-condensable gases such as air without letting

steam escape [reference 7]. Much like individual's mentality that resources should not be wasted, steam traps allow for the steam that is being used regularly for heating as a driving force not be wasted [reference 7]. As shown in figure 1 with small fluctuations in temperature some steam flowing through the steam trap turns into condensate which is ineffective for the overall power that the system needs. The condensate formed then flows to the bottom of the ball steam trap and flows out, while the steam flows upward to be used throughout the system. This ball steam trap system allows for the condensate to flow down and have the chance to revert back to steam or flow out and be reused again (Figure 1).

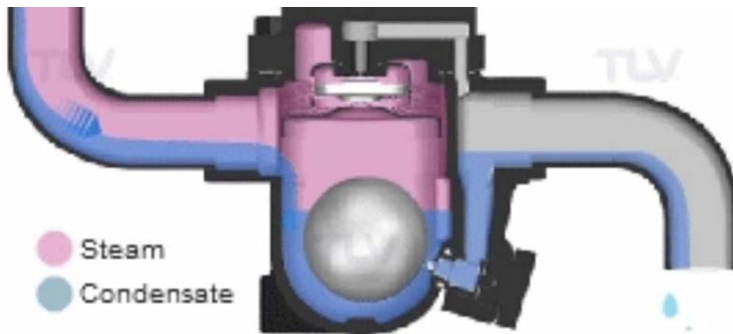


Figure 1: Illustration of performing steam trap.

Steam traps provide efficiency within the driving force of the system due to the heating efficiency of the steam. Condensate degrades the heating efficiency of the system therefore it is carried out within the steam trap.

While steam traps allow for heating efficiency of the system to be good, failure points are another way efficiency can be decreased. Failure points in and around a steam trap allow for steam to blow out, dirt particles to be in a leaking or plugged steam trap, and drastic pressure changes [reference 6]. While many manufacturing and power plants use the plan of performing regularly scheduled steam trap surveys, identify the issue, use ultrasound or another form of failure point detection, identify specifically the problem and act appropriately, many plants don't

do this due to the lack of time or resources [reference 6]. Therefore, the other direction some plants take is to quickly visually inspect or hear any deformities within or around the steam trap. This alternate direction to the plan set out at other plants mostly requires an experienced engineer or technician to hear out for the change in frequencies which can be difficult with a fully operational plant in the background. For an experienced engineer listening to failure points in a steam trap it is very difficult and infrequent to actually detect something up until the frequency has drastically changed or a major malfunction that alters most of the system occurs. This lack of recognition of the failure points within steam traps can affect production efficiency, increase maintenance costs, and create huge safety issues for employees. Having a huge liability in one's hands due to a small portion of an entire system, detection of failure points in steam traps is vital to analyze quickly. With this in mind the element of sound and analysis of frequency of a steam trap and the pipes surrounding it can advise an engineer of the steam traps state, whether it needs to be inspected further or leave as is.

Methodology

Sound in steam traps and the surrounding pipes are a big part of the detection of failure points. With the use of ultrasound equipment detecting and isolating the signal one can then listen to the steam and condensate sounds more accurately. Although ultrasound is effective and offers results in real time, it does not offer results all the time and through a certain number of hours or days. Having ultrasound to detect the sound within the steam trap when one is measuring it is beneficial but knowing the sound and having a visual graph of the sound frequency provides more of a background of the conditions of the steam trap. Providing a software system that allows audio to be inputted in real time and provide moving visual graphs of the sound and the frequency can help engineers determine any failure points and how they occurred. The software MatLab allows for data to be inputted, analyzed, and turn into a neural

network that can output an answer needed. With this in mind, MatLab with the application Signal Analyzer one can input sound, have it analyzed for its frequency, and have the output be whether it is a failure point of the steam trap system or in good condition.

As shown below MatLab offers the user to be able to input steam trap audio bites from a plant, have it be analyzed and offer a model, then output for a reporting of the condition of the system in real time as shown in figure 2 [reference 4].

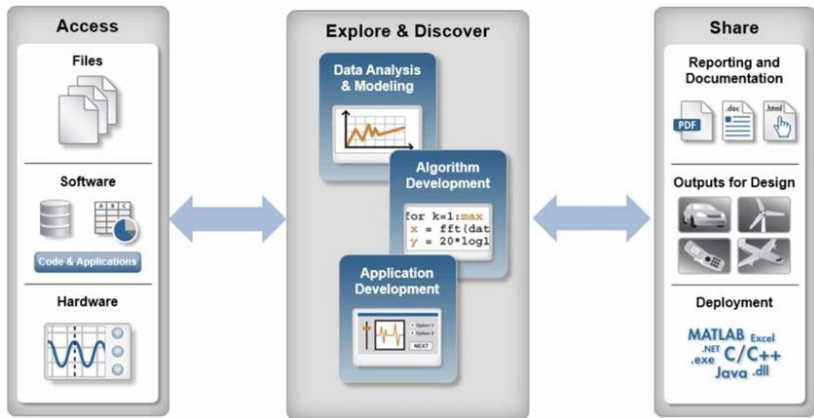


Figure 2: Shows how MatLab is designed for the process of inputting file and having the ultimate output be a report or what the condition is based on the researcher working on the project.

To start with this research, audio bites of different frequency were used to establish the types of data that the system will have to detect when inputting an actual steam trap audio file. By doing this the main core flow of access, explore and discover, and share is applied, but more specific to the case of sound bites, graphs, and frequency detection as shown in figure 3.

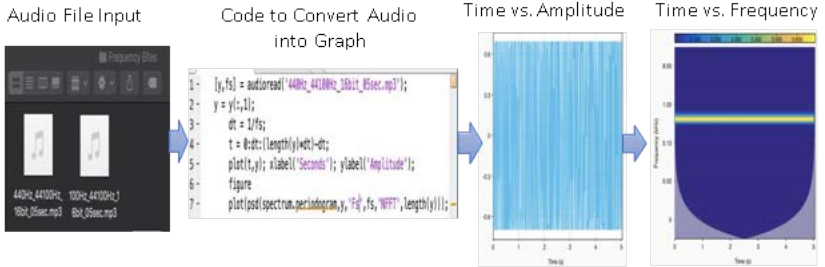


Figure 3: Flow diagram of the process to input frequency audio file and the outcome of frequency detection.

For this research project, 440Hz and 100Hz sound files for frequency were used and embed into MatLab. By using the code shown below one can translate these audio files and make them into time vs. amplitude graphs to show the pattern of the continuous sound for each frequency as shown in figure 4.

```

1- [y,fs] = audioread('440Hz_44100Hz_16bit_05sec.mp3');
2- y = y(:,1);
3- dt = 1/fs;
4- t = 0:dt:(length(y)*dt)-dt;
5- plot(t,y); xlabel('Seconds'); ylabel('Amplitude');
6- figure
7- plot(psd(spectrum.periodogram,y,'Fs',fs,'NFFT',length(y)));

```

fs	44100
m	222336x1 double
t	1x222336 double
y	222336x1 double

```

1- [m,fs] = audioread('100Hz_44100Hz_16bit_05sec.mp3');
2- m = m(:,1);
3- dt = 1/fs;
4- t = 0:dt:(length(m)*dt)-dt;
5- plot(t,m); xlabel('Seconds'); ylabel('Amplitude');
6- figure
7- plot(psd(spectrum.periodogram,m,'Fs',fs,'NFFT',len100gth(m)));

```

fs	44100
m	222336x1 double
t	1x222336 double
y	222336x1 double

Figure 4: Code from MatLab that embeds each audio file and outputs time vs. amplitude graph.

Having these files and their time components graphs saved, opening the signal analyzer app and transferring the 440Hz and 100Hz graphs, then changing the designated x axis to the time component, these graphs can then be analyzed and changed to the information and graph needed [reference 5]. Changing the viewing of each graph to a time-frequency scalogram one can easily detect the yellow line of high magnitude to show what frequency it is. Below shows the time vs. amplitude and time vs frequency graphs that represent the identification of the transferring of the audio file to visually detect the frequency.

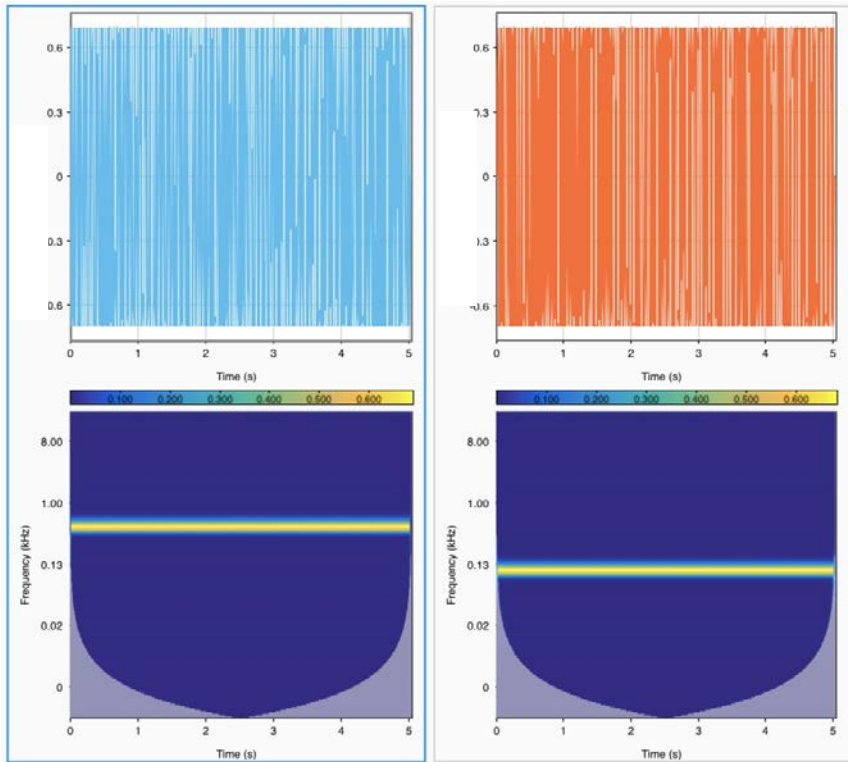


Figure 5: Time vs. amplitude graph and time vs. frequency graphs for frequency 440Hz and 100Hz

These developments show that by having a continuous audio file of frequency one can see by the time vs. frequency graphs the frequency it is. By having more audio files inputted into the software the more specific the software will be when detecting audio from steam traps that in real time have different frequencies at different points in time.

Results & Future Work

The results of the audio files being transferred to show the frequency in a scalogram graph is a development in which shows that the transfer to continuous sound of a steam trap into this software can show in real time the frequency that is being heard.

To obtain better results, as mentioned, one has to input more sound files of different frequencies in order for the software to learn more specifically about them. Due to the differentiating frequencies in steam traps the end goal would be to have each of the frequencies identified and classified to their designated frequencies, this can be achieved with the deep learning application within MatLab. Through deep learning, building a neural network with convolutional layers will be essential to the output command process of each frequency from the steam trap as shown in figure 6 [reference 8]. With each convolutional layer trained to look at each pixel from the scalogram graph and see which has the most yellow/orange color. From there the frequency can be shown and by using audio labeled within that final layer, let that piece of frequency be labeled as 440Hz for example. Through constant files being recorded and input into the software each close to similar frequency will be evaluated through each layer and/or pixels and output in real time that frequency.

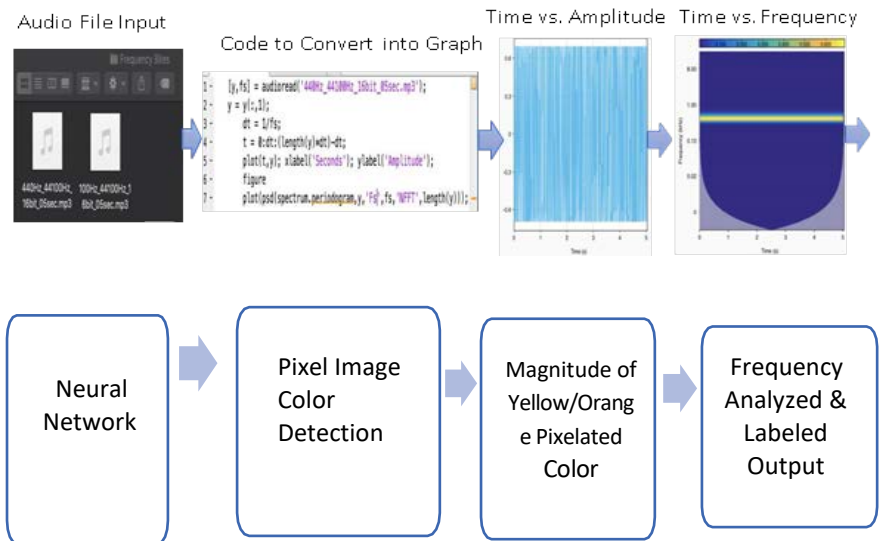


Figure 6: Shows the future work process when integrating neural networks.

Conclusion

This research and its future works provide engineers the chance to use deep learning, audio analyzer, and audio labeler within MatLab to identify in real time the different frequencies emitted from the steam trap sound. With this process employees can look at previous days of the frequency information and develop data on their own to see when they need to replace a steam trap, when a steam trap started to go into critical condition, or even test out which steam trap is more effective over time. This project reduces time, increases efficiency, and decreases production cost due to the real time visualization of a steam trap.

References

[1]

Evans, R. P., Blotter, J. D., and Stephens, A. G. (May 3, 2004). "Flow Rate Measurements Using Flow-Induced Pipe Vibration." ASME. J. Fluids Eng. March 2004; 126(2): 280–285. [Accessed: 24-Jun-2020].

[2]

Yang, Ming-Der. 2008. Automated Diagnosis of Sewer Pipe Defects Based on Machine Learning Approaches, Expert Systems with Applications. 3rd ed. Vol. 35. Taiwan: National Chung Hsing University. [Accessed: 24-Jun-2020].

[3]

“U.S. Energy Information Administration - EIA - Independent Statistics and Analysis.” 2019. What Is the Efficiency of Different Types of Power Plants? - FAQ - U.S. Energy Information Administration (EIA).

<https://www.eia.gov/tools/faqs/faq.php?id=107&t=3>. [Accessed: 24-Jun-2020].

[4]

K. K. Devleker, “Signal Analysis Made Easy - Video,” Video - MATLAB, 2015. [Online].

Available: <https://www.mathworks.com/videos/signal-analysis-made-easy-100811.html>. [Accessed: 24-Jun-2020].

[5]

B. Zotto,”Plotting wav sound file onto graph,” Plotting wav sound file onto graph-MATLAB Answers - MATLAB Central, 16-Sep-2016. [Online]. Available:

<https://www.mathworks.com/matlabcentral/answers/303114-plotting-wav-sound-file-onto-graph>. [Accessed: 24-Jun-2020].

[6]

B. Gorelick and A. Bandes, “Why Do Steam Traps Fail?,” UE Systems, 2019. [Online].

Available: <https://www.uesystems.com/why-do-steam-traps-fail/>. [Accessed: 24-JUN-2020].

[7]

“What is a Steam Trap?,” TLV, 2019. [Online]. Available:

<https://www.tlv.com/global/US/steam-theory/what-is-a-steam-trap.html>. [Accessed: 24-Jun-2020].

[8]

G. Bunkheila, “Introduction to Deep Learning for Audio and Speech Applications Video,” Video-MATLAB & Simulink, 2019. [Online]. Available:

<https://www.mathworks.com/videos/introductions-to-deep-learning-for-audio-and-speech-applications-1560448385032.html>. [Accessed: 26-Jun-2020].

The Effect of Host-country Investment Environment and Foreign State-owned Firm Involvement on Private versus Host-country Public Ownership of Investment Projects

Jessica Flores

Mentor: Barclay James, Ph.D.
St. Mary's University, San Antonio, TX

In this study, I examine how the investment environment of a host country and the presence of a foreign state-owned multinational enterprise (SO MNE) effect the ownership structure (i.e., private or public ownership) of investment projects located in multiple countries. When firms engage in foreign direct investment (FDI), they manage risks related to the host-country investment environment. For example, countries vary in the extent to which they protect shareholders and enforce contracts. More recently, there has been an increase in the presence of state-owned firms engaging in FDI. These state-owned multinational enterprises (SO MNEs) may be perceived by host-country states and their citizenry as relatively less legitimate than privately-owned multinational enterprises (PO MNEs), as SO MNEs may have politically- motivated incentives for their foreign direct investment (FDI) decisions. At the same time, many SO MNEs may also have substantial bargaining power relative to host-country states due to political and economic dependency of the host country on the home country of the SO MNE. In the bargaining for ownership of investment projects, lower legitimacy may cause host-country states to retain more ownership themselves. But greater dependency by host-country states on the SO MNEs' home country might restrict host-country states resistance to foreign SO MNE ownership. Based on

a sample of 489 energy investment projects located across 49 developing countries, I find that 1) host-country investment quality is negatively associated with host- country state (i.e., public) ownership, and 2) foreign SO MNE involvement is negatively associated with host-country state (i.e., public) ownership. My study contributes to international business and strategy research about how host-country investment environment and SO MNE involvement affect foreign ownership structure of FDI. Key words: state-owned multinational enterprises, foreign direct investment, investment projects, institutional environment, ownership structure

INTRODUCTION

When multinational enterprises (MNEs) engage in foreign direct investment (FDI), they must make decisions about the ownership structure of these investments (e.g., how much equity in in foreign projects). Such decisions are based in part on a host country's environment related to how it protects investors and promotes economic exchange (e.g., strength of the legal system) (North, 1990). Host-country governments ("states") establish and enforce laws for foreign MNEs investing in their countries. Host-country states also may view foreign private (i.e., non- state-owned) MNEs (PO MNEs) differently than foreign state-owned MNEs (SO MNEs). SO MNEs, compared to PO MNEs, may have political motivations related to desires of their home-country governments/states (Duanmu, 2014). SO MNEs sometimes hold government appointed board members, which may reduce legitimacy in the eyes of foreign countries. Unlike PO MNEs, SO MNEs are financially supported by their government, therefore they may be able to invest in higher costing projects. Additionally, past research has theorized the idea that large countries seeking political power in countries lacking financial power will invest heavily through their SOMNEs, which could increase the dependency of host country on the SO MNE's home country.

In highly-developed countries, considerable investment protection exists for foreign MNEs. But in less developed (“developing”) countries, policies and their enforcement may be lacking. Further, developing-country states may be particularly vulnerable to dependency by foreign MNEs, especially if they are SO MNEs. In this study, I examine how variation in the quality of the investment environment across developing countries affect the ownership structure of investment projects. In particular, in politically-sensitive industries such as infrastructure (e.g., energy), foreign MNEs and host-country states might both be bargaining for ownership of critical investment projects, like a power plant. These types of investment projects often but not always include ownership by the host-country state (“public” ownership). It is likely that a higher-quality investment environment may assuage foreign MNEs’ concerns, which may result in more foreign MNE equity compared to equity by the host-country state, in an investment project. That is, in developing countries with better investment environments (e.g., stronger legal system), I propose and test that investment projects will have less host-country state (i.e., public) ownership (Hypothesis 1).

Further, I examine how the presence of a foreign SO MNE may affect investment project ownership structure. The result of SO MNE involvement on the ownership structure of an investment project (like a power plant) is not clear. SO MNEs may be perceived as less legitimate than PO MNEs, but SO MNEs may also have substantial bargaining power relative to host-country government, due to economic dependency of the host country on the SO MNE’s home country. There are further risks. For example, researchers have observed when analyzing the investments of SO MNEs vs PO MNEs in host countries with high technological advantages in a certain project refrain from allowing SO MNEs to invest because they want to refrain

possible technology information leakage between the host and home country. Researchers have studied FDI for decades. For example, Lewis (1938, 1948) was one of the first researchers to bring light to the analysis of international private investment flows by charting the growth of foreign direct investment in the late 19th and early 20th centuries. But, there has been less research on understanding the role of SO MNEs in FDI. Based on considerations of legitimacy and bargaining power of SO MNEs, I develop two competing hypotheses. I hypothesize that the presence of a SO MNE in an investment project will be associated with more host-country ownership (Hypothesis 2a) or less host-country ownership (Hypothesis 2b).

To test my hypotheses, I collected a sample of 489 investment projects in the energy industry, across 48 developing countries. The sample includes projects with sponsoring MNE that is either from the United States (US) or from mainland China (China). In the energy industry, a large majority of US-based MNEs in this sample are not state-owned while a large majority of Chinese-based MNEs in this sample are state-owned. Therefore I am able to determine, albeit with the lack of some precision, how a SO MNE affects investment project ownership structure. I find that host-country state ownership in an investment project is lower in countries with better investment environments, and it is also lower if the investment project includes an SO MNE (i.e., Chinese MNE). The remaining sections are as follows. First, I develop my hypotheses by reviewing background literature and outlining the reasons for my propositions (i.e., hypotheses). Then, I describe the methods I use to test my hypotheses (e.g., sample and data). Then, I report the results. Finally, I conclude the study with a discussion of the implications of the study and limitations.

Host-country Investment Environment

When MNEs invest abroad, they face risks related to the establishment and enforcement of policies/laws that differ across countries. Vernon (1971) explained why host-country governments may renege on policies that govern FDI through an obsolescing bargain theory, which argues that a deal which appeared attractive to a government becomes less attractive over time, especially to a new government that may be in power. Vernon also discusses political change and competition, which can happen within a short period of time. This occurs during events like elections, where personnel from several or all levels are changed at the same time. Furthermore, governments can use their multiple roles in these infrastructure projects to renegotiate contracts “voluntarily.”

Rammurti (2003) highlights different characteristics private firms should keep an eye out for when investing in foreign countries, to ensure promises made by the host-country’s government are kept throughout their business working together, since many countries are known to change details in previously agreed terms when new government officials are brought into office. Governments are more involved in infrastructure projects than people realize, holding roles at every level but producer. The term “privatization” hides the truth that many of these firms are indeed public-private ventures, having partial influence by the government. Further, renegeing is not always preplanned. Many governments enter contracts in good faith, and at a later time may renege on the deal. Governments may renege is due to economic uncertainty. Although private investors may try their best to plan for the worst, the future may have unforeseen events that a piece of writing cannot prepare for. When these unanticipated events arise, contracts are forced to be renegotiated. Historically, research has shown that foreign private investors are drawn to developed countries that avoid risks associated with developing countries. For example, firms may be more likely to invest in countries with greater policy stability, which can result from more “checks” on policy changes after firms invest (Henisz, 2000; Henisz and Macher, 2004). Although economic development does not have a direct correlation with institutional

advancement, the instability of the country offers no relying legal protection for investors (Doh, Teegen, Mudambi, 2004). Host-country ownership in investment projects may be higher in host countries with a lower quality investment environment. In countries that lack legal protections for investors, those investing firms may limit their ownership (Delios and Beamish, 1999). Also, if firms cannot rely on a country's legal-institutional environment, firms may reduce risk by partnering as owners with the host-country state (James and Vaaler, 2018). Developing countries with lower investment quality might also be associated with governments that wish to retain some ownership over critical infrastructure for political reasons. Therefore, I expect that a greater investment climate for investors will be associated with lower host-country state ownership.

Hypothesis 1: Projects located in countries with higher-quality investment environments will be associated with less project ownership by the host-country government.

Legitimacy and Bargaining Power of Foreign State-owned Multinationals

SO MNEs may have different incentives than PO MNEs for their investments abroa, and host-country states may also view SO MNEs and PO MNEs differently. SO MNEs can be perceived as a threat to the hosts' national security because they are directly linked to their home government. Golberman and Shapiro (2009) look at Chinese outward FDI into the US and discuss the political opposition that may occur when SO MNEs gain large acquisitions of host-country firms. They also note a lack of structural and organizational transparency of Chinese state-owned enterprises. Another concern relates to investment activities of Chinese MNEs that may be subsidized by the Chinese government. This means they may have an unfair capital cost advantage compared to privately-owned firms that finance their investments at market costs of capital.

Duanmu (2014) analyzes how international political factors can contribute to SO MNEs' exposure to expropriation risk. Looking at Chinese firms as examples, Duanmu explains how China's

outward FDI may be portrayed as politically motivated. Sometimes host countries perceive interactions with SO MNEs as opportunities to build positive relationship with the home country of the SO MNE, and therefore may strive to building a good working relationship with some SO MNEs in hopes of economic and political gains later.

Meyer, Li, Ding, and Zhang (2014) suggest that state-owned enterprises face harsher pressures in host countries than private firms due to different factors that pertain to them that do not necessarily pertain to privately-owned enterprises. The authors test whether the ownership type of multinational enterprises will affect the strategies used to enter foreign markets. One example of SO MNEs being seen as more of a threat than PO MNEs is when entering countries with strong technological advantages. Technology leakage is a strategy that some corporations use with the intention to take that knowledge back into their home countries to use for their advantage.

Many factors contribute to the outcomes of negotiations between host states and investors. Doh, Teegen, and Mudambi (2004) identify institutional, firm and project factors that influence the balance of state versus private ownership of new telecommunication projects. They use variables specific to firms and projects such as entry mode and governance structure to test the influence of these variables on the private ownership of newly consummated projects. As they expected, they found in their data that a country's economic development as measured by gross domestic product (GDP) per capita greatly influences private ownership and control of projects. They also found that their proposed alternative that low tariffs enhanced a state's overall attractiveness for FDI showed no association with private ownership shares. They also found that private ownership level has a curvilinear relation to investment policy hazards. Private ownership is lowest where investment policy hazards are either very few or very high, but higher when hazards show moderate risk ranges.

Cuervo-Cazurra, Inkpen, Musacchino & Ramaswamy (2014) develop several propositions related to SO MNEs' outward FDI. One proposition is that SO MNEs are more likely to invest in larger projects abroad compared to PO MNEs. This is assumed to be because SO MNEs know that their government has sufficient funds to bail them out if a project with high risk does not perform as planned. They also propose that SO MNEs are more likely to select host countries in which their state-owned is seen as more legitimate. Another proposition made by this study is that SO MNEs typically prefer greenfield operations, which are new and started from scratch, rather than acquisitions and therefore avoid controversy that may arise by a foreign state-owned firm buying a domestic firm. Related to resource dependence theory, these authors also suggest a power escape argument. In relationships among two parties, one party is able to exercise power over the other when the latter depends on the first for a resource. This theory highlights the traditional history of politicians holding seats in a company's board of directors, therefore they usually appoint their own managers to run the company. Thus, politicians may still be able to influence a company's decisions to pursue political objectives that have little value to the firm but high value to the politician himself.

As past research has shown, many times state-owned sponsoring firms are thought to be motivated by political strategies rather than only by economic strategies when investing in foreign economies. Projects in infrastructure, such as in energy, may leave a country dependent on its investors. When host countries have negative perceptions of SO MNEs, they may be hesitant on making themselves dependent on a foreign firm.

When multiple firms invest in a single project, the firm with the higher percentage of ownership may reflect greater relative bargaining power, or at least may reflect relative control over project operations. Thus, projects with SO MNEs involved as owners may be associated with more project ownership by the host-country government, in attempt to lower the dependency on a foreign government. But, the opposite effect might occur. That

is, host- country ownership in projects might be lower if those projects involve a SO MNE. Therefore, I propose two competing hypotheses:

Hypothesis 2a: Projects with foreign state-owned sponsoring firms, compared to projects with foreign privately-owned sponsoring firms, will be associated with more project ownership by the host-country government.

Hypothesis 2b: Projects with foreign state-owned sponsoring firms, compared to projects with foreign privately-owned sponsoring firms, will be associated with less project ownership by the host-country government.

METHOD

To test our hypotheses, we collected data from several sources. We constructed a dataset of projects initiated between 1996 and 2018 from the World Bank’s Private Participation in Infrastructure (PPI) database, which includes infrastructure project information (e.g., host country, sector, government support) for projects located in developing countries. The World Bank Group is made up of five institutions, forming one of the world’s largest sources of knowledge for developing countries. The group shares a commitment to help developing countries reduce poverty and promote sustainable development. Infrastructure development, particularly in rural areas, may help in poverty reduction (Fan, Zhang, and Zhang, 2002). From the early 1980s on, the World Bank’s PPI provides international project information pertaining to infrastructure projects. From the 10,691 observations downloaded, we used those projects which met the following characteristics: “energy” sector projects, projects located in developing countries except for China (because we focus on “foreign” SO MNE involvement), projects in which a sponsoring firm is from either China or the United States (in order to contrast SO MNEs and PO MNEs), resulting in a final data set of 489 observations from 49 developing countries¹.

The dependent variable is *Percent Host-State Owned*, which indicates the percentage of equity ownership in a project

by the host-country state/government. Table 1 shows all variables used along with their measurements, data sources, and descriptive statistics.

Table 1: Variable Descriptions and Predictions

Variables	Measurement	Source	Mean	SD.	Min.	Max.
Percent Host-State Owned	Percentage of equity ownership by the host-	World Bank's Private Participation in	90.57	17.18	30.00	100.00
Project Size	Total cost in US\$ of the	World Bank's Private in Infrastruc	235.32	411.20	1.20	3753.00
Acquisition	0-1 dummy variable indicating whether the	World Bank's Private Participation in	0.13	0.34	0.00	1.00
InGDP	Natural logarithm of host-country gross	World Bank's World Development Indicators	25.99	1.79	20.97	28.59
GDP per	GDP per capita of the host country in current US \$	World Bank's World Development	4924.32	3662.12	294.16	13245.61
Exports	Total exports of the country as a percentage of host-	International Monetary Fund	73065.6	87643.1	255.4	396913.1
Exports to China	Exports of the host country to China as a percentage of total	Internati onal Monetar	0.06	0.06	0.00	0.32
Exports to US	Exports of the host country to US as a total exports	Internati onal	0.20	0.19	0.00	0.89
Invest ment Quality	Average score of the Heritage Foundation's Economic	Heri tage Fou ndat ion	60.33	6.74	40.00	76.30
Chinese Firm	0-1 dummy variable that equal Chinese sponsoring firm (an equity owner from a firm domiciled in mainland China)	World Bank's Private in Infrastruc ture (PPI)	0.18	0.38	0.00	1.00

¹ These 49 countries are

RESULTS

Table 2 shows the pairwise correlations between our variables. Table 3 shows our results after running a regression. To test my hypotheses, I used ordinary least squares (OLS) regression. Column 1 in Table 2 shows the results for only the control variables. Column 2 adds the two key variables to test Hypothesis 1 (*Investment Quality*) and Hypotheses 2a and 2b (*Chinese Sponsoring Firm*). The estimated coefficient for *Investment Quality* is negative and statistically significant (i.e., $p < 0.05$), which is consistent with Hypothesis 1. This result means that investment projects located in host countries with better institutions—to protect investors and facilitate economic transactions—have more private rather than public host-state ownership. The estimated coefficient for *Chinese Sponsoring Firm* is negative and statistically significant (i.e., $p < 0.10$), which is consistent with Hypothesis 2b. This result suggests that projects with foreign state-owned enterprises (Chinese sponsoring firms) will be associated less project ownership by the host-country government compared to a project with a foreign privately-owned sponsor.

Table 2: Correlation Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) Percent Host Government	1.00									
(2) Project Cost	0.16 (0.00)	1.00								
(3) Project Type	0.09 (0.04)	-0.12 (0.01)	1.00							
(4) lnGDP	0.06 (0.21)	0.05 (0.24)	-0.32 (0.00)	1.00						
(5) GDP per capita	0.04 (0.37)	-0.04 (0.39)	-0.21 (0.00)	0.69 (0.00)	1.00					
(6) Exports	0.06 (0.17)	0.06 (0.16)	-0.26 (0.00)	0.76 (0.00)	0.65 (0.00)	1.00				
(7) Exports to China	0.06 (0.21)	0.07 (0.15)	-0.15 (0.00)	0.43 (0.00)	0.50 (0.00)	0.48 (0.00)	1.00			
(8) Exports to US	0.01 (0.00)	0.02 (0.00)	0.17 (0.00)	-0.14 (0.00)	-0.16 (0.00)	0.03 (0.00)	-0.37 (0.00)	1.00		
(9) Investment Quality	-0.09 (0.05)	-0.16 (0.00)	0.23 (0.00)	-0.12 (0.01)	0.15 (0.00)	-0.21 (0.00)	-0.24 (0.00)	0.09 (0.06)	1.00	
(10) Chinese Sponsoring Firm	-0.08 (0.08)	0.19 (0.00)	-0.18 (0.00)	0.09 (0.04)	0.05 (0.26)	0.16 (0.00)	0.31 (0.00)	-0.12 (0.01)	-0.27 (0.00)	1.00

Table 3. Regression Results

Independent Variables:	(1)	(2)
Project Size	0.01*** (0.002)	0.01*** (0.002)
Project Type	5.75** (2.463)	6.30** (2.499)
lnGDP	-0.52 (0.811)	-0.87 (0.815)
GDP per capita	0.00 (0.000)	0.00 (0.000)
Exports	0.00** (0.000)	0.00* (0.000)
Exports to China	44.89** (18.687)	37.66* (19.257)
Exports to US	-2.45 (4.925)	-2.82 (4.892)
Investment Quality		-0.38** (0.149)
Chinese Sponsoring Firm		-3.88* (2.270)
Constant	76.67*** (20.648)	45.76* (23.654)
Year dummy variables	Yes	Yes
Number of Observations	489	489
R-squared	0.127	0.144

Standard errors in parentheses
 *** p<0.01, ** p<0.05, * p<0.1

CONCLUSION

We sought to examine how the investment environment of a host country and the presence of a foreign SO MNEs effect the ownership structure (i.e., private or public ownership) of investment projects located in multiple countries. The result of SO MNE involvement on the ownership structure of an investment project (like a power plant) is not clear. SO MNEs may be perceived as less legitimate than PO MNEs, but SO MNEs may also have substantial bargaining power relative to host-country government, due to economic dependency of the host country on the SO MNE’s home country.

Due to there being less research on understanding the role of SO MNEs in FDI, I based my study on considerations of legitimacy and bargaining power of SO MNEs. I develop two competing hypotheses. I hypothesize that the presence of a SO

MNE in an investment project will be associated with more host-country ownership (Hypothesis 2a) or less host-country ownership (Hypothesis 2b).

REFERENCES

Cuervo-Cazurra, A., Inkpen, A., Musacchio, A., & Ramaswamy, K. (2014). Governments as owners: State-owned multinational companies. *Journal of International Business Studies*, 45(8), 919-942.

Delios, A., & Beamish, P. (1999). Ownership strategy of Japanese firms: Transactional, institutional, and experience influences. *Strategic Management Journal*, 20: 915-933.

Doh, J. P., Teegen, H., & Mudambi, R. (2004). Erratum: Balancing private and state ownership in emerging markets' telecommunications infrastructure: Country, industry, and firm influences. *Journal of International Business Studies*, 35(5), 459-459.

Duanmu, J. (2014). State-owned MNCs and host country expropriation risk: The role of home state soft power and economic gunboat diplomacy. *Journal of International Business Studies*, 45(8), 1044-1060.

Explore the Data. (n.d.). Retrieved June 26, 2020, from <https://www.heritage.org/index/explore>

Fan, S., Zhang, L.X., & Zhang, X. B. (2002). Growth, inequality, and poverty in rural China: The role of public investments. research report 125, International Food Policy Research Institute, Washington, D.C.

Gartzke, E., Li, Q., & Boehmer, C. (2001). Investing in the Peace: Economic Interdependence and International Conflict. *International Organization*, 55(2), 391-438.

Globerman, S., & Shapiro, D. (2008). Economic and strategic considerations surrounding Chinese FDI in the United States. *Asia Pacific Journal of Management*, 26(1), 163-183.

Heilperin, M. A. (1949). The United States and Foreign Investment Problems. By Cleona Lewis. (Washington, D. C.: The Brookings Institution. 1949. Pp. xviii, 359. \$3.00.) - Foreign Economic policy for the United States. Edited By Seymour E. Harris. (Cambridge, Mass.: Harvard University Press. 1948. Pp. xiii, 490. \$6.00.). *American Political Science Review*, 43(5), 1043-1046.

Henisz, W. (2000). The institutional environment for economic growth. *Economics and Politics*, 12: 1- 31.

Henisz, W., & Macher, J. (2004). Firm- and country-level tradeoffs and contingencies in the evaluation of foreign investment: The semiconductor industry, 1994-2002. *Organization Science*, 15: 537-554

James, B. E., & Vaaler, P. M. (2018). Minority rules: Credible state ownership and investment risk around the world. *Organization Science*, 29(4), 653-677.

Landman, J. (1939). LEWIS, CLEONA. America's Stake in International Investments. Pp. xvi, 710. Washington: Brookings Institution, 1938. \$4.00. *The ANNALS of the American Academy of Political and Social Science*, 201(1), 253-254.

Meyer, K. E., Ding, Y., Li, J., & Zhang, H. (2014). Overcoming Distrust: How State-Owned Enterprises Adapt their Foreign Entries to Institutional Pressures Abroad. *JIBS Special Collections State-Owned Multinationals*, 211-251.

(n.d.). Retrieved June 26, 2020, from <https://www.imf.org/external/index.htm>

Morrow, J. D., Siverson, R. M., & Tabares, T. E. (1998). The Political Determinants of International Trade: The Major Powers, 1907–1990. *American Political Science Review*, 92(3), 649-661.

Noreng, O. (1996). 96/01346 National oil companies and their government owners: The politics of interaction and control. *Fuel and Energy Abstracts*, 37(2), 92.

North, D. (1990). *Institutions, institutional change and economic performance*. Cambridge, UK: Cambridge University Press.

Pollins, B. M. (1989). Does Trade Still Follow the Flag? *American Political Science Review*, 83(2), 465-480.

Ramamurti, R. (2003). Can governments make credible promises? Insights from infrastructure projects in emerging economies. *Journal of International Management*, 9(3), 253-269.

Solow, R. M. (1956). A Contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics*, 70(1), 65.

Suchman, M. C. (1995). Managing Legitimacy: Strategic and Institutional Approaches. *The Academy of Management Review*, 20(3), 571.

Swan, T. W. (1956). ECONOMIC GROWTH and CAPITAL ACCUMULATION. *Economic Record*, 32(2), 334-36.

World Development Indicators. (n.d.). Retrieved June 26, 2020, from <https://databank.worldbank.org/source/world-development-in>

Colchicine and its effects on monocytes, macrophages, and inflammation

John Sanchez

Mentor: Veronica Contreras-Shannon, Ph.D.
St. Mary's University, San Antonio, TX

Atherosclerosis, or the hardening of the arteries, is due to the formation of lipid plaques within the walls of the arteries. This chronic inflammatory disease plagues millions of Americans. Currently the best way to treat atherosclerosis is to treat the risk factors associated with the disease. Interestingly, research demonstrates how closely connected microtubules are to the pathogenesis of the chronic inflammation giving rise to atherosclerosis proving they could be a new target for therapies. Microtubules play a role in the functions of monocytes and macrophages which contribute to the pathogenesis of atherosclerosis. Some of the functions enabled by microtubules include cytokine secretion, assembly of the NLRP3 inflammasome, and phagocytosis. In this review, I examine the effects of colchicine on monocytes and macrophages described in experiments involving colchicine and monocytes and macrophages. Because colchicine binds to microtubules and prevents their assembly, this review seeks to clarify whether colchicine could alter the cytokine secretion, assembly of the NLRP3 inflammasome, and phagocytosis that contribute to the development of atherosclerosis. Recent studies show colchicine reduces pro- and anti-inflammatory cytokine secretion, blocks the assembly of the NLRP3 inflammasome, and inhibits the expression of adhesion molecules involved in phagocytosis. In summation, several studies demonstrate that colchicine disrupts multiple mechanisms of inflammation distinctive of atherosclerosis. This suggests that targeting microtubule function in monocytes and macrophages may have utility in treating atherosclerosis and acute coronary syndromes (ACS) that result from these inflammatory pathways.

Introduction

Atherosclerosis, or the hardening of the arteries, is due to the formation of lipid plaques within the walls of the arteries.(Bobryshev et al., 2016) This chronic inflammatory disease is the underlying cause for 50% of the deaths in western societies.(Pahwa and Jialal, 2020) Atherosclerosis begins with damage to endothelial cells lining the walls of arteries. This damage, which occurs for several reasons, allows low-density lipoprotein (LDL cholesterol) to enter the arterial intima.(Pahwa and Jialal, 2020) Typically, monocytes in the blood are also floating freely in the blood, however these will attach to the walls of the arteries near the damage when damaged endothelial cells begin expressing adhesion molecules. This attachment causes these activated monocytes to undergo a change that allows them to flatten and squeeze between endothelial cells and enter the intima becoming macrophages.(Pahwa and Jialal, 2020) Macrophages inside the intima produce reactive oxygen species (ROS) that oxidize LDL.(Linton et al., 2000) This oxidized LDL is what recruits and activates more monocytes.(Linton et al., 2000) This creates a positive feedback situation in which more oxidized LDL and monocytes accumulate within the artery wall.

Once in the artery wall, macrophages begin to ingest the oxidized LDL leading to the formation of a foam cell.(Pahwa and Jialal, 2020) When foam cells die, they release LDL and other macrophages ingest the release cholesterol.(Linton et al., 2000) Dead cells and LDL begin to form a plaque which is then covered by new endothelial cells.(Linton et al., 2000) The plaque grows overtime through the accumulation of dead cells and cholesterol.(Linton et al., 2000) This plaque can advance in severity with the formation of a thrombus, the coagulation of platelets.(Linton et al., 2000) Thrombus formation can result in myocardial infarctions, sudden cardiac death, and stroke.(Linton et al., 2000)

Monocytes and macrophages clearly play a large role in the pathogenesis of the atherosclerosis. As described prior, they are involved in the uptake of cholesterol, secretion of cytokines

and the formation of plaque on arterial walls becoming foam cells.(Bobryshev et al., 2016) These macrophages are responsible for the secretion of pro-inflammatory cytokines such as IL-1 β which drive the continued recruitment of macrophage to the artery.(Bobryshev et al., 2016) Lastly, macrophages are responsible for the phagocytosis of microbes. In the case of atherosclerosis, phagocytosis is a mechanism by which cholesterol is absorbed into the cell.

Typically phagocytosis is a defense mechanism that is used to clear out invading pathogens and debris caused by injury.(Harrison and Grinstein, 2002) The mechanism of phagocytosis depends on cytoskeleton whose support allows for the engulfment and elimination of microbes in the phagolysosome.(Harrison and Grinstein, 2002)

These inflammatory events utilized by monocytes and macrophages depend heavily on microtubules. Microtubules are dynamic protein structures that undergo dynamic instability and assembly meaning that they are continuously growing and shrinking at either end.(Patel et al., 2009) Microtubules are commonly known for their roles in maintaining the cytoskeleton, intracellular transport, phagocytosis, as well as protein secretion.(Patel et al., 2009) Microtubules are needed for intracellular transport of proteins to the cell membrane and without microtubules, protein secretion is reduced.(Rennison et al., 1992) Therefore, this would be true for cytokines secreted that are responsible for the pro-inflammatory cycle of macrophage recruitment and foam cell formation. Additionally, the importance of microtubules in monocytes and macrophage function can be elucidated by studying the effect of colchicine (and other microtubule-binding drugs) on the functions of these cells. Colchicine is a microtubule binding drug that has been shown to disrupt microtubule stability. Typically, colchicine is used to treat gout and Familial Mediterranean Fever (FMF) because of its anti-inflammatory effects.(Leung et al., 2015) Colchicine affects many inflammatory mechanisms that enable its use in treating gout.(Dalbeth et al., 2014) In addition to these

diseases, colchicine and other microtubule binding drugs could be a potential therapy for atherosclerosis. The goal of this review is show how colchicine affects monocytes and macrophages functions that are key events in the pathogenesis of atherosclerosis, and how the disruption of pro-inflammatory mechanisms from these cells may aid in reducing atherosclerotic inflammation.

Colchicine affects Cytokine Secretion

Several studies have demonstrated that colchicine reduces the secretion of cytokines. Patients with acute coronary syndrome (ACS) were administered colchicine. This caused the patients' monocytes and macrophages to secrete fewer cytokines, specifically IL-1 β , IL-18 and IL-6.(Martínez et al., 2015) These cytokines are key inflammatory agents involved in the pathogenesis of atherosclerosis.(Martínez et al., 2015) It was shown that colchicine significantly decreased the presence of these cytokines in the blood.(Martínez et al., 2015) In a similar study it was shown that monocytes from ACS patients secreted fewer IL-1beta and IL-18 when treated with colchicine.(Robertson et al., 2016)

The decrease in cytokine secretion is due in part to the absence of the NLRP3 inflammasome. This protein is linked to the secretion of these pro-inflammatory cytokines, and a functioning inflammasome depends on proper microtubule function in order to be assembled.(Yang et al., 2019) One thing to note, is that in the second study, the intracellular levels of pro-IL-1 β and IL-18 were unaffected by colchicine. This suggest that not only may microtubules play a role in the activation of IL-1 β but are necessary for the secretion of cytokines such as IL-18. In fact, microtubules are needed for intracellular transport of these proteins to the cell membrane.(Rennison et al., 1992)

Colchicine affects Phagocytosis

In one experiment macrophages were treated with 10⁻⁶ M colchicine. These cells experienced a decrease in their ability to phagocytose red blood cells from sheep, only being 58% effective compared to macrophages that were not treated with

colchicine.(Piasek and Oblakowski, 1985) In another study, neutrophils, the most abundant white blood cell in the blood, are treated with colchicine.(Lehrer, 1973) The researchers observe a decrease in the ability of neutrophils to phagocytose polystyrene.(Lehrer, 1973)

As described above, microtubules are necessary for phagocytosis. It has been shown that during phagocytosis, microtubules undergo reorganization.(Harrison and Grinstein, 2002) Although the experiment referenced involved the studies of receptors present on macrophages for antibodies, the mechanism of internalization is undoubtedly similar. Another example involves complement mediated phagocytosis, which involves the CR3 complement receptor, also requires proper microtubule organization.(Zhou et al., 2001) These two mechanisms demonstrate that organization of microtubule is necessary for phagocytosis no matter which receptor is involved nor what is being internalized.

Conclusion

Above I have presented and described the potential colchicine, and perhaps other microtubule drugs, may have in controlling inflammation that is a result of normal monocyte and macrophage function. As the above evidence shows, colchicine can disrupt inflammatory events that contribute to atherosclerosis. The next step would be to review more papers to explore more mechanisms of inflammation from monocytes and macrophages that are affected by colchicine. In addition, the effects of other microtubule binding drugs should be explored.

- Bobryshev, Y.V., Ivanova, E.A., Chistiakov, D.A., Nikiforov, N.G., and Orekhov, A.N. (2016). Macrophages and Their Role in Atherosclerosis: Pathophysiology and Transcriptome Analysis. *BioMed Res. Int.* 2016.
- Dalbeth, N., Lauterio, T.J., and Wolfe, H.R. (2014). Mechanism of Action of Colchicine in the Treatment of Gout. *Clin. Ther.* 36, 1465–1479.
- Harrison, R.E., and Grinstein, S. (2002). Phagocytosis and the microtubule cytoskeleton. *Biochem. Cell Biol.* 80, 509–515.
- Lehrer, R.I. (1973). Effects of Colchicine and Chloramphenicol on the Oxidative Metabolism and Phagocytic Activity of Human Neutrophils. *J. Infect. Dis.* 127, 40–48.
- Leung, Y.Y., Hui, L.L.Y., and Kraus, V.B. (2015). Colchicine --- update on mechanisms of action and therapeutic uses. *Semin. Arthritis Rheum.* 45, 341–350.
- Linton, M.F., Yancey, P.G., Davies, S.S., Jerome, W.G., Linton, E.F., Song, W.L., Doran, A.C., and Vickers, K.C. (2000). The Role of Lipids and Lipoproteins in Atherosclerosis. In *Endotext*, K.R. Feingold, B. Anawalt, A. Boyce, G. Chrousos, K. Dungan, A. Grossman, J.M. Hershman, G. Kaltsas, C. Koch, P. Kopp, et al., eds. (South Dartmouth (MA): MDText.com, Inc.), p.
- Martínez, G.J., Robertson, S., Barraclough, J., Xia, Q., Mallat, Z., Bursill, C., Celermajer, D.S., and Patel, S. (2015). Colchicine Acutely Suppresses Local Cardiac Production of Inflammatory Cytokines in Patients With an Acute Coronary Syndrome. *J. Am. Heart Assoc. Cardiovasc. Cerebrovasc. Dis.* 4.
- Pahwa, R., and Jialal, I. (2020). Atherosclerosis. In *StatPearls*, (Treasure Island (FL): StatPearls Publishing), p.
- Patel, P.C., Fisher, K.H., Yang, E.C.C., Deane, C.M., and Harrison, R.E. (2009). Proteomic Analysis of Microtubule-associated Proteins during Macrophage Activation. *Mol. Cell. Proteomics* 8, 2500–2514.

- Piasek, A., and Oblakowski, P. (1985). Influence of Colchicine and Cytochalasin B on Pinocytosis, Phagocytosis, and Antibody-Dependent Cell-Mediated Cytotoxicity. In *Modern Trends in Human Leukemia VI New Results in Clinical and Biological Research Including Pediatric Oncology*, R. Neth, R.C. Gallo, M.F. Greaves, and G. Janka, eds. (Berlin, Heidelberg: Springer), pp. 511–513.
- Rennison, M.E., Handel, S.E., Wilde, C.J., and Burgoyne, R.D. (1992). Investigation of the role of microtubules in protein secretion from lactating mouse mammary epithelial cells. *J. Cell Sci. 102 (Pt 2)*, 239–247.
- Robertson, S., Martínez, G.J., Payet, C.A., Barraclough, J.Y., Celermajer, D.S., Bursill, C., and Patel, S. (2016). Colchicine therapy in acute coronary syndrome patients acts on caspase-1 to suppress NLRP3 inflammasome monocyte activation. *Clin. Sci. 130*, 1237–1246.
- Yang, Y., Wang, H., Kouadir, M., Song, H., and Shi, F. (2019). Recent advances in the mechanisms of NLRP3 inflammasome activation and its inhibitors. *Cell Death Dis. 10*, 1–11.
- Zhou, X., Li, J., and Kucik, D.F. (2001). The microtubule cytoskeleton participates in control of beta2 integrin avidity. *J. Biol. Chem. 276*, 44762–44769.

Meeting the Need: Understanding “Servingness” at Hispanic-serving Institutions

Micaela S. Cruz

Mentor: Rick Sperling, Ph.D.

St. Mary’s University, San Antonio, TX

Our Lady of the Lake University (OLLU) is a small, liberal arts university located in San Antonio, Texas. OLLU enrolls a large percentage of Latinx (62.7%) students. Consequently, it has been designated as a Hispanic-serving Institution (HSI). While this designation would seem to suggest that OLLU represents an important mechanism for social justice because it forefronts the identities of Latinx students, one cannot simply assume that is true from title alone. There are important differences between being designated as an HSI and committing to the mission of Latinx-centric education. Many institutions use their status as an HSI to compete for federal funds and then neglect to implement programs and activities that are geared toward helping Latinx students specifically. In this paper, I explore the conceptual limitations of the HSI designation, as well as recent literature on metrics for gauging “servingness” (Garcia, 2020b). It is against this backdrop that I evaluate the extent to which OLLU centralizes their HSI status and consider the important historical event that may have contributed to their current level of commitment to Latinx students. Results suggests that OLLU far exceeds what is expected of HSIs as determined by the US Department of Education and is in constant pursuit of a morally and ethically sound method of delivering culturally responsive education. Based on those results, I provide recommendations for how other HSIs can be more responsive to the needs and desires of their Latinx students.

Keywords: Hispanic-serving Institutions (HSIs), “servingness,” Our Lady of the Lake University (OLLU), Hispanic Association of Colleges and Universities (HACU)

The Pew Research Center (2015) projects that by the year 2060, there will be 119 million Latinx people, which translates to 29% of the entire population of the United States (Colby & Ortman, 2015). These figures have important implications for equity in higher education. Consider the following: As of 2017, 3.5 million Latinx were enrolled in nonprofit colleges and universities yet only 17.2 percent of Latinx adults had acquired at least a bachelor's degree, as compared to 53.9% of Asians, 38.1% of Whites, and 24.3% of African-Americans (HACU).

One reason for these disparate outcomes is that despite landmark cases, such as *Brown v. Board of Education* (1954), the US system of higher education has always been racially segregated with most Black, Latinx, and American Indian students attending minority-serving institutions (MSIs; Turner, Baez & Gasman, 2008). However, while these institutions share a mutual understanding that they serve a disproportionately high percentage of racial/ethnic minority students, understanding the diversity of institutional type under the umbrella MSI term is critical. Whereas tribal schools and historically Black colleges and universities (HBCUs) were designed with their respective populations in mind, no such schools exist for Latinx students (Garcia, 2019a, p. xii).

The 1980s and 1990s saw an increase in the number of Latinos enrolling in higher learning institutions in the United States and a corresponding increase in attention to discrepancies in service (Santiago, 2012). In 1986, a conglomerate of educators, having recognized the significance of poverty, language barriers, and other structural impediments that were hindering Latinx students from reaching their full academic potential, created the Hispanic Association of Colleges and Universities (HACU) to advocate for colleges and universities that served the majority of Latinx students. There was near immediate impact. Just six years later Congress accepted a HACU proposal to designate these colleges and universities as Hispanic-serving Institutions (HSIs).

From the start, the HSI designation was statistical rather than purpose driven. Congress decided that to qualify as an HSI, a

two-year or four-year college or university must have a full-time, Latinx undergraduate enrollment of 25%. As of 2018, 492 have met these criteria. However, many of these institutions were not founded with the intention of serving Latinx students (Garcia & Ramirez, 2018; Núñez, Hurtado, & Calderón Galdeano, 2015). Rather, the designation merely reflects the government's desire to improve low college enrollment and degree completion rates amongst Latinx students (Gasman, 2008; Santiago, 2012). As Vela and Gutierrez (2017) note, there has been a failure to address the “metrics impacting, measuring, and incentivizing successful matriculation, and graduation rates of the Hispanic/Latinx students” (p. 10)

Given the apathy toward genuinely educating Latinx students, one wonders why colleges and universities would bother to apply for the HSI designation in the first place. Per usual, the answer is money. On average, HSIs are underfunded and the designation serves as a means of accessing funding from the U.S. Department of Education Developing Hispanic-Serving Institutions Program (Carter & Patterson, 2019). It is therefore Latinx students and their identities that bring money into the HSI whether the HSI even gestures toward acknowledging the demographics of its student body or not.

This motivation is real because, as previously discussed, HSIs are known to be underfunded. Citing a lack of institutional resources, some researchers have argued that HSIs are not fully capable of serving their students in ways other institutions are able to (de los Santos & Cuamea, 2010). They point to evidence suggesting a significant association between institutional resources and graduation rates (Rodríguez & Calderón Galdeano, 2015). Indeed, HSIs “receive an average of 69 cents for every federal dollar granted to all postsecondary institutions” (HACU, 2017; para. 4). Furthermore, as Mulnix, Bowden and Lopez (2002) report, a majority of HSIs almost entirely depend on funding from the state and federal government. Many HSIs are underequipped, understaffed, and unable to maintain research

facilities, offer high-tech learning and working environments, or develop undergraduate or graduate programs (Benitez, 1998).

The severity of under-funding raises questions regarding the quality of education and future opportunities for students at HSIs. Questions such as “[D]o HSIs have adequate resources to face up the difficult task of education a student population that lags behind in practically every academic indicator?” or another question being “Are Hispanic students better off at HSIs than at other institutions that are stronger financially and academically?” (Benitez, 1998; p. 61).

Lack of funding notwithstanding, HSIs still have a responsibility, given the resources they have, to operate with the interests of their Latinx students in mind. This is a complicated charge, and even the originator of the HSI concept cannot be called upon for help. HACU, known to be the voice for HSIs in the United States and “essential to shaping the postsecondary landscape for HSIs,” influences how organizations should function, but it does not provide instructions on what individual institutions ought to do (Garcia, 2019a; p. 95). Rather, we must turn to the literature for the most cutting edge thinking if we are to arrive at a serviceable answer.

Defining Servingness

The concept of “servingness” was first introduced by Gina Garcia in 2019 and was used to describe the ability of colleges and universities to “provide transformative experiences that lead to both academic and nonacademic outcomes” (p. 1). According to Garcia, this is done by first meeting the enrollment requirements of 25% Latinx students and 50% low-income students and then proceeding to educate in culturally-responsive ways.

The concept of “servingness” begets a typology for HSIs, which if applied uniformly, would be beneficial for several reasons. First, it would allow researchers to categorize and disaggregate HSIs in analyses and for sampling (Núñez, Crisp & Elizondo, 2016). Second, it would aid institutional leaders from both established and emerging HSIs in understanding the extent

to which their institutions are similar or different (Núñez, Crisp & Elizondo, 2016). Third, it would allow for HSIs to be separately categorized and for their institutional performance to be compared to others (Rodriguez & Calderón Galdeano, 2015).

The four typologies developed by Garcia were: *Latinx-enrolling*, *Latinx-producing*, *Latinx-enhancing*, and *Latinx-serving*. To begin, an institution that is *Latinx-enrolling* meets the minimum of having 25% enrollment of Latinx students but does not produce desirable outcomes nor allow for the enhancement of racial/ethnic experiences for their Latinx students (Garcia, 2019). An institution that is *Latinx-producing* meets the minimum 25% enrollment threshold of Latinx students while also producing positive outcomes; however, the development of the culture of success for their Latinx students is left wanting (Garcia, 2019). A *Latinx-enhancing* institution is one that satisfies the 25% enrollment threshold and has an enhancing racial/ethnic culture but does not produce equitable outcomes (Garcia, 2019). The best achievable identity of an HSI is to be an institution that is identified as “*Latinx-serving*.” Garcia (2019) suggests that *Latinx-serving* institutions incorporate the following: meeting the minimum of 25% enrollment of Latinx students, production of equitable institutional outcomes, and implement a positive racial/ethnic experience that is educationally enhancing and welcoming for their Latinx students.

To reiterate, HSIs are responsible for properly serving their Latinx students and to adopt the idea of “servingness,” an approach that will “provide transformative experiences that lead to both academic and nonacademic outcomes” (Garcia, 2019a). After conducting an in-depth case study of a four-year HSI, Garcia developed the *Typology of HSI Organizational Identities* that is composed of four different quadrants. Each quadrant was developed based on how members in the study would construct the “ideal” HSI identity, stemming from “institutional ways of knowing and aspects of their unique culture” (Garcia, 2019a; p. 31). Participants from the study stated that HSIs should produce desirable outcomes used to measure institutional success in

regards to serving their students (e.g., graduation rates), as well as enacting a culture that “enhances the racial/ethnic experience of Latinx students” (Garcia, 2019a; p. 49).

Elaborating beyond the general idea of “servingness,” scholars have stated that the organizational culture of an institution is an essential element to properly serving students at HSIs, as well as utilizing campus climate measures to assess “servingness” (Garcia, Núñez & Sansone, 2019; Franco & Hernandez, 2018). This argument was further elaborated on by other researchers who stated that HSIs must “provide culturally sustaining practices that promote equitable outcomes” (Malcom-Piqueux & Bensimon, 2015; p. 11). Such practices include diversity within institutional faculty and graduate student population, as well as culturally relevant curriculum and advising practices (Contreras, 2017; Garcia & Okhidoi, 2015).

An important element that contributes to furthering desirable and equitable institutional outcomes would be the institution’s mission statement. Adopting a mission statement that draws attention to Hispanic/Latinx students “provides guidance for faculty, staff, and administration to reach these desired outcomes” (Vela & Gutierrez, 2017). Furthermore, mission statements assist in providing guidance to the institution’s faculty “for working independently and collectively to reach the expected level of institutional performance” (Ekpe, Eneh & Inyang, 2015; p. 135).

OLLU: Historical Origins

This section discusses the background of Our Lady of the Lake University and various important events surrounding the institution. Much of the data referenced in this section can be found online on the school’s website (<https://ollusa.edu/about/history.html>). Established by the Sisters of the Congregation of Divine Providence, Our Lady of the Lake University, formerly known as Our Lady of the Lake College, was founded in 1895. Prior to becoming a full-fledge university, the institution first began as an all-girl high school in 1896, serving primarily young White women as indicated by a photo on

the school website. The institution later transitioned to providing a two-year college curriculum for women in 1911. The structure of the school later changed from a two-year to a four-year university in 1919. During the 1940s, the faculty consisted primarily of CDPs, or the Sisters from the Congregation of Divine Providence, and the student population was composed of “young middle class Anglo women from San Antonio,” although “daughters of upper class families from Latin America were a small but steady component.” Other individuals from neighboring towns and states were also on campus (Morkovsky, 2009). In 1942, Our Lady of the Lake University began offering coeducation graduate study programs, before making all programs co-educational in 1969. A statement from one of the Sisters of Divine Providence recognized a changing student body during the 1970s, as she stated “We opened our admissions more broadly and were on the leading edge of...an inner-city school. We began to make a direct effort to incorporate Hispanic students...to help train them to go teach their own” (Morkovsky, p. 79). Aside from seeing more diversity within the student population, Our Lady of the Lake saw an abundance of new ventures aimed for their Hispanic students. By the fall of 1972, 60% of OLLU students were Mexican American and 80% depended on financial aid (Morkovsky, 2009). Through assistance from federal grants, a staff working on a project known as “Project Puerta Abierta” searched the Southwest region for talented, prospective Mexican American students from low income families, who were then offered scholarships (Morkovsky, 2009).

In regards to the Mexican-American culture, Our Lady of the Lake University has witnessed key historical events such as hosting the U.S. Commission on Civil Rights Hearing on Mexican Americans in the Southwest in 1968, a 50th Anniversary conference in 2018 honoring the 1968 Civil Rights commission and being chosen to house the National Institute of Mexican American History of Civil Rights in 2020. Another important event occurred in June of 1970, where a public forum on “La

Raza and the Violation of Civil Rights in Texas” took place on the Our Lady of the Lake campus. In attendance were Senator Joe Bernal and Mario Compeán, member of the Mexican American Youth Organization (MAYO; Morkovsky, 2009). Another La Raza conference occurred at Our Lady of the Lake campus in March of 1971 where Secretary of Health, Education, and Welfare (HEW) Eliot Richardson addressed concerns that HEW had been primarily focusing on the Black minority and not to the Chicano population (Morkovsky, 2009). It is important to note that organizations such as MAYO and La Raza Unida Party (RUP) were active and rooted in the San Antonio area during the late 1960s through the early 1970s and were behind the organized Chicano political activism of that time. Our Lady of the Lake students contributed to the activism by organizing a summer seminar on “the Chicano” following the 1971 conference. Later, a group referred to as the “Concerned Students of OLL” presented a position paper to the school’s administration requesting the “immediate institution of a Chicano studies program” (Morkovsky, 2009; p. 85). The students’ request was granted, and an ethnic studies program was inaugurated in 1972 (Morkovsky, 2009).

By the beginning of the 20th century, Our Lady of the Lake University transformed into an institution whose student body was predominantly comprised of middle and lower class Latinx students (Morkovsky, 2009). OLLU was later recognized by the *Hispanic Magazine* in March 2001 as being one of the top 20 colleges and universities for Latinx. The criteria for inclusion were Hispanic enrollment, retention, and graduation, academic excellence, number of Latinx student organizations and support programs, and number of Latinx faculty (Morkovsky, 2009). Overall, Our Lady of the Lake University has developed substantially from the time the institution was first established in 1895 to now in the 21st century.

OLLU: 2010 to the present

Our Lady of the Lake University (OLLU) is a small, liberal arts university located on the West side of San Antonio,

Texas. Statistics from the fall 2019 semester showed that the total undergraduate enrollment was 1,365 students, and the total graduate enrollment was 1,698 students. The student body is comprised of more women than men. Non-binary students were not reported. Regarding race and ethnicity, the highest enrollment percentage stems from the Latinx students (62.7%), whereas almost as many Black students (12.5%) attend OLLU as White students (14.9%). Neither the Asian nor the American Indian student representation tops one percent.

A 2016 study utilizing cluster analysis was conducted to provide a foundation for understanding institutional diversity among HSIs. OLLU was included in Cluster 4, identified as “Small Communities Four Years.” Institutions in this cluster were located in areas of high levels of educational attainment, however, they had a lower percentage of Latinx faculty (Núñez, Crisp & Elizondo, 2016). In the past two decades, OLLU has seen five different presidents: Sally Mahoney (1997-2001), Dr. Robert E. Gibbons (2001-2002), Dr. Tessa Martinez Pollack (2002-2013), Sister Jane Ann Slater, CDP, Ph.D. (2013-2015), and Diane E. Melby, Ed.D. (2015-present). All but one of the institution’s past presidents have been White, with Dr. Pollack being the first the only Latinx to hold the presidency. However, an ethnic diversity breakdown of OLLU’s faculty showed that 45.6 percent of the faculty were Latinx, 41.6% of the faculty was White, 7.2% of the faculty was Black, and 2.1% of the faculty was Asian (College Factual).

It is also important to consider their mission statement, the academic curriculum, campus resources and organizations, and retention rates. OLLU is unique in that they have both a mission statement and a vision statement. Their vision statement reads:

“Inspired by Catholic values and the heritage of the found Congregation of Divine Providence, Our Lady of the Lake University is a community called to transform individuals as they discover their purpose in life. We aspire to be nationally recognized for our distinctive programs, our expertise in Mexican

American culture, and our diverse graduates who lead and serve with faith and wisdom to improve the world” (OLLU, para. 2).

As for the mission statement, OLLU is a community whose members, assuming the faculty and administration, are committed to serve their students in three important ways: “ensuring quality, innovative undergraduate and graduate learning experiences; fostering spiritual, personal, and professional growth; and preparing students for success and continued service” (OLLU, para. 1). Specifically, the vision statement highlights the desire of the school to be recognized for their knowledge in Mexican American culture. OLLU has managed to accomplish this through the establishment of the Center for Mexican American Studies and Research (CMASR), whose mission is “dedicated to drawing on our expertise as a Hispanic Serving Institution, steeped in the rich Mexican American culture and history of San Antonio’s Westside,” and by also “...supporting the University in fulfilling its mission as a Catholic Hispanic Serving Institution...” (OLLU, para. 1, 2). By offering a degree in Comparative Mexican American Studies, having on-campus organizations such as the Association of Latino Professionals for America (ALPFA) and the Bilingual Education Student Organization (BESO), OLLU provides additional evidence that they are intentionally serving their Latinx students.

Lastly, I wish to briefly discuss the retention rates of OLLU. According to the Integrated Post-secondary Educational Data System (IPEDS), the retention rate for first-time full-time students pursuing bachelor’s degrees beginning in fall 2017 was 68%. The overall graduation rate, which tracks the progress of OLLU students “who began their studies as full-time, first-time degree- or certificate-seeking students to see if they complete a degree or other award...within 150% of ‘normal time’ for completing the program in which they are enrolled,” for fall 2013 was 42 percent (NCES, para. 7). The six-year graduation rate for Latinx was 44% as compared to 48% for Whites and 28% for Blacks (NCES, para. 7).

OLLU: Putting it All Together

Since the institution was established in 1895, OLLU has evolved to address various changes and challenges, and has become stronger in diversity and in their culture, perhaps influenced by their location in the Westside of San Antonio. Recall that the first students who attended OLLU, while it was at first a high school, were young White women, mostly daughters from high-income families. However, OLLU was recognized in 2019 for attracting the largest percentage of Latinx undergraduates of any private university in the nation (U.S. News and World Report, 2020 Best Colleges).

In addition to quantitative evidence, there is also anecdotal evidence that OLLU more than properly serves their Latinx students to the best of its ability. According to one employee who was also a graduate of a less Latinx-serving institution in San Antonio, “The OLLU professors I have come across aim to empower their students. Knowing Hispanics are seen as the minority and understanding we can be at somewhat of a disadvantage, means our students need to be more prepared by graduation. By OLLU focusing on Hispanic heritage, students are confident, motivated, and given a voice they did not know they had” (Anonymous, personal communication, June 12, 2020). Working toward continuously developing a strong Mexican American campus culture fulfills one aspect of what it means to be *Latinx-serving*. As the OLLU employee aptly stated, “...focusing on Mexican American heritage at an HSI will only benefit the students by creating a well-rounded professional, who advocates for themselves and others” (Anonymous, personal communication, June 12, 2020).

An ideal *Latinx-serving* institution is one that meets the minimum of 25% enrollment of Latinx students, one that produces equitable institutional outcomes, and implements a positive racial/ethnic experience that is educationally enhancing and welcoming for their Latinx students (Garcia, 2019). Institutions must expend considerable effort to properly be identified as a *Latinx-serving* institution. Regarding OLLU,

without any issue, the institution greatly satisfied the minimum 25% enrollment threshold for Latinx students, with an enrollment percentage of 62.7% in the fall of 2019. The retention and overall graduation rates are not the highest in the nation; however, the faculty and administration are continuing to work hard in order to provide an interactive academic environment with diverse administration and faculty members who promote success and strive to provide greater educational opportunities for furthering one's knowledge of the Mexican American heritage and culture. OLLU supports the CMASR that is dedicated to student success, faculty development, and community engagement in the Mexican American-Latino communities. In addition to CMASR, OLLU has institutionalized several other organizations geared toward Latinx students that provide strong, positive experiences that are both welcoming and educationally enhancing.

Overall, Our Lady of the Lake University is aware of its demographics and needs of its student body. Rather than forcing assimilation through, and perhaps unnecessary, curriculum, advising, recruiting/advertising, OLLU engages its students in the process of self-discovery that will produce better career opportunities and a healthier way of seeing themselves. To be more than an HSI in name only is to show the utmost dedication to your students, to show that the institution they attend is one that cares about both their education, their academic and non-academic experiences, and most importantly, their well-being. Structurally speaking, it is key that HSIs have the following: a meaningful mission statement that outlines the goals each member should hope to achieve, a diverse and multi-cultural administration and faculty who can provide different perspectives and opinions, a curriculum that is pertinent and applicable to students' lives and future careers, and student organizations that promote *conscientização* (Freire, 1971). Other institutions, including those that share geographic and demographic similarities and espouse similar religious views are encouraged to follow the example that OLLU has set for academic excellence,

moral/ethical integrity, and the provision of a socially just education for Latinx students.

References

- “Fairly Typical in Racial Diversity” OLLU Demographics: How Diverse Is It? *College Factual*.
<https://www.collegefactual.com/colleges/our-lady-of-the-lake-university-san-antonio/student-life/diversity/>
- Benitez, M. (1998). Hispanic Serving Institutions: Challenges and opportunities. In J. P. Merisotis & C. T. O’Brien (Eds.), *Minority Serving Institutions: Distinct purposes, common goals*, 102, (pp. 57-68). San Francisco: Jossey-Bass.
- Carter, T. L., & Patterson, J. A. (2019) A Community College HSI: The Effect of an HSI Designation on Organizational Identity. *Community College Review*, 47(4), 360-381.
- Colby, S. L., & Ortman, J. M. (2015). Projections of the Size and Composition of the US Population: 2014 to 2060. Population Estimates and Projections. Current Population Reports. P25-1143. *US Census Bureau*.
- Contreras, F. E. (2017). Latino faculty in Hispanic-Serving Institutions: Where is the diversity? *Association of Mexican American Educators Journal*, 11, 223–250. doi:10.24974/amae.11.3.368
- de los Santos, A. G., Jr., & Cuamea, K. M. (2010). Challenges facing Hispanic-serving institutions in the first decade of the 21st century. *Journal of Latinos and Education*, 9(2), 90–107.
- Ekpe, E. O., Eneh, S. I., & Inyang, B. J. (2015). Leveraging Organizational Performance through Effective Mission Statement. *International Business Research*, 8(9), 135.
- Franco, M. A., & Hernández, S. (2018). Assessing the Capacity of Hispanic Serving Institutions to Serve Latinx Students: Moving Beyond Compositional Diversity. *New Directions for Institutional Research*, 2018(177), 57–71. <https://doi-org.blume.stmarytx.edu/10.1002/ir.20256>
- Freire, P. (1971). *Pedagogy of the Oppressed*. Modern Classics.

- Garcia, G. A. (2019a). *Becoming Hispanic-Serving Institutions : Opportunities for Colleges and Universities*. Johns Hopkins University Press. 49–140.
- Garcia, G. A. (2020b) *Hispanic Serving Institutions (HSIs) in Practice: Defining “Servingness” at HSIs*. Information Age Publishing.
- Garcia, G. A., Núñez, A.-M., & Sansone, V. A. (2019). Toward a Multidimensional Conceptual Framework for Understanding “Servingness” in Hispanic-Serving Institutions: A Synthesis of the Research. *Review of Educational Research*, 89(5), 745–784. <https://doi-org.blume.stmarytx.edu/10.3102/0034654319864591>
- Garcia, G. A., & Okhidoi, O. (2015). Culturally relevant practices that “serve” students at a Hispanic Serving Institution. *Innovative Higher Education*, 40, 345–357. doi:10.1007/s10755-015-9318-7
- Garcia, G. A., & Ramirez, J. J. (2018). Institutional agents at a Hispanic serving institution: Using social capital to empower students. *Urban Education*, 53(3), 355– 381.
- Gasman, M. (2008). Minority-serving institutions: A historical backdrop. In M. Gasman, B. Baez, & C. S. V. Turner (Eds.), *Understanding Minority-serving Institutions*. Albany: State University of New York.
- Gasman, M., Baez, B., & Turner, C. S. V. (Eds.). (2008). *Understanding Minority-serving Institutions*. SUNY Press.
- Hispanic Association for Colleges and Universities. (2017). [Graph illustration HSI Growth: 1994-2015]. 2017 Fact Sheet: Hispanic Education and HSIs. Retrieved from https://www.hacu.net/hacu/HSI_Fact_Sheet.asp
- Hispanic Association for Colleges and Universities. (2019). 2019 Fact Sheet: Hispanic Higher Education and HSIs. Retrieved from https://www.hacu.net/hacu/HSI_Fact_Sheet.aspst
- Integrated Post-secondary Educational Data System. Retention and Graduation Rates. *National Center for Education*

- Statistics*. Retrieved from <https://nces.ed.gov/collegenavigator/?id=227331#outcome>
- Malcom-Piqueux, L., & Bensimon, E. M. (2015). Design principles for equity and excellence at Hispanic-serving institutions. Retrieved from http://education.utsa.edu/images/uploads/30207-PerspectivasPolicyBrief_Issue4-2.pdf
- Morkovsky, M. C. (2009). *Living in God's providence: history of the Congregation of Divine Providence of San Antonio, Texas, 1943-2000*. XLibris Corp.
- Mulnix, M. W., Bowden, R. G., & Lopez, E. E. (2002). A Brief Examination of Institutional Advancement Activities at Hispanic Serving Institutions. *Journal of Hispanic Higher Education, 1*(2), 174-190.
- National Center for Education Statistics. (?) *Retention and Graduation Rates*. Retrieved from <https://nces.ed.gov/collegenavigator/?id=227331#outcome>
- Núñez, A.-M., Crisp, G., & Elizondo, D. (2016). Mapping Hispanic-Serving Institutions: A Typology of Institutional Diversity. *Journal of Higher Education, 87*(1), 55–83.
- Núñez, A.-M., Hurtado, S., & Calderón Galdeano, E. (2015). Why study Hispanic-serving institutions? In A.-M. Núñez, S. Hurtado, & E. Calderón Galdeano (Eds.), *Hispanic-serving institutions: Advancing Research and Transformative Practices* (pp. 1–22). New York, NY: Routledge.
- Rodríguez, A., & Calderón Galdeano, E. (2015). Do Hispanic-serving institutions really underperform? Using propensity score matching to compare outcomes of Hispanic Serving and non-Hispanic-Serving Institutions. In A.-M. Núñez, S. Hurtado, & E. Calderón Galdeano (Eds.), *Hispanic-Serving Institutions: Advancing Research and Transformative Practice* (pp. 196–216). New York: Routledge.
- Santiago, D. A. (2012). Public policy and the Hispanic-Serving Institutions: From invention to accountability. *Journal of*

Latinos and Education, 11, 163-167. doi:
10.1080/15348431.2012.686367

Vela, M. & Gutierrez, P. (2017) The Hispanic Population and Hispanic Serving Institutions. *eJEP: eJournal of Education Policy*.

Applications of Pyridoxal Phosphate in Various Enzymatic Reactions

Maralba C. Perez

Mentor: Xinghai Chen, Ph.D.

St. Mary's University, San Antonio, TX

A fundamental concept in the studies of biochemistry are biological catalysts called enzymes. It is crucial for a functioning enzyme to be assisted by coenzyme. One of the many coenzymes is (4-formyl-5-hydroxy-6-methylpyridin-3-yl)methyl dihydrogen phosphate abbreviated Pyridoxal Phosphate (PLP), and is vital for the occurrence of a variety of transamination, decarboxylation, and deamination reactions. In transamination reactions, the PLP acts as an amino carrier and is a coenzyme that is capable of catalyzing different reactions. The rule the coenzyme PLP is summarized. PLP works as coenzyme in many other reactions such as decarboxylation, elimination, racemization, retro-aldol cleavage, but the first step of all mechanisms of enzymatic reactions is similar to the process of transamination. Pyridoxal Phosphate is the active form derived from Vitamin B₆ which helps elaborate its importance to our system. As PLP is the active form of pyridoxine, pyridoxine is of great importance in the biosynthesis of neurotransmitters and lipids. Imperative chemicals such as dopamine and serotonin cannot be produced without pyridoxine. A pyridoxine deficiency can affect blood, skin, heart, and neurological systems especially in patients of malnutrition, alcoholism, as well as pregnant woman.

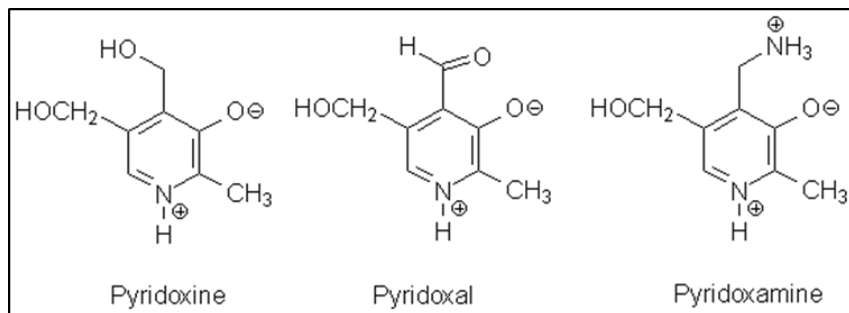


Fig. 1. Courtesy of “No Excuses Health” entry. Structural group of Vitamin B6. Pyridoxal is generally the most common form of Vitamin B6, and is widely used for metabolism of amino acids. Pyridoxine is used for the biosynthesis of neurotransmitters and lipids.

Background

The first form of Vitamin B₆ to be identified was pyridoxine in 1938, the active derivative were later identified in the mid 1940's. The active form of Vitamin B₆ is pyridoxal phosphate, however Vitamin B₆ can exist in other forms of 3-hydroxy-2-methylpyridine. These derivatives include pyridoxine, pyridoxal, and pyridoxamine. The derivatives of Vitamin B₆ are inactive until becoming chemically phosphorylated through protein kinases. In fact, the only Vitamin B₆ derivative that can become active is pyridoxal to pyridoxal-5-phosphate and a small portion of pyridoxamine. Vitamin B₆ occurs majorly in two forms pyridoxine and pyridoxamine, and is then converted to pyridoxal phosphate with the enzyme pyridoxal kinase in the liver and other tissues. In this case, pyridoxal phosphate is of greater importance.

In order for pyridoxal to become pyridoxal phosphate, the enzyme pyridoxal kinase must be used. Pyridoxal kinase catalyzes the transfer of phosphate from ATP to the HOCH₂ branch of the derivatives of Vitamin B₆. Once PLP is active, it attaches itself onto the residue of an amino acid which in most cases is a lysine residue. The amino group of lysine replaces the amino group on the amino acid substrate. This attachment is noted as a Schiff-base linkage or internal aldimine and activates the apo enzyme. This linkage is the common first and last step of

each reaction, and the process is called transamination. These so called enzymes are considered Pyridoxal Phosphate Dependent Enzymes, and follow out reactions like transamination, decarboxylation, substitution-elimination, racemization, and retro-aldol cleavage. In actuality, these reactions are those responsible for amino acid metabolism, nucleic acid biosynthesis, neurotransmitter biosynthesis, and more.

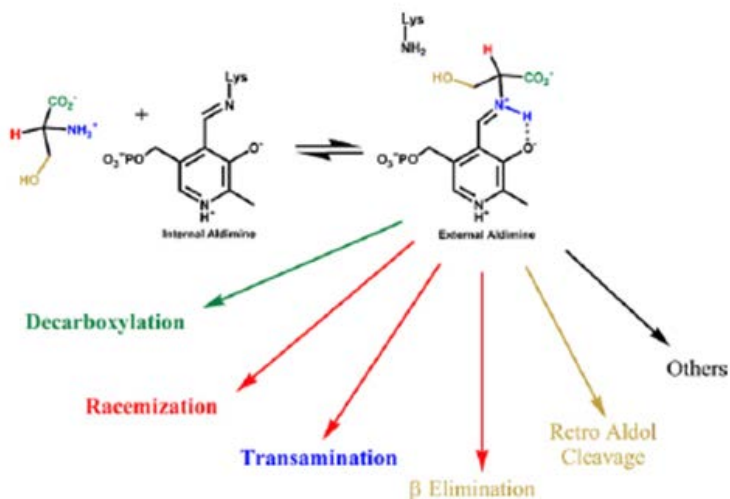


Fig. 2. Courtesy of M.D. Toney. Archives of Biochemistry and Biophysics 433 (2005) 279–287 Major types of pyridoxal phosphate dependent enzymatic reactions.

Transamination

All PLP Dependent enzyme reactions have the same first and last step in mechanisms, this step is referred to transamination. Transamination is the transfer of an amino group to a ketoacid, or carboxylic acid and ketone group. This process is completed through the assistance of aminotransaminase enzymes. Transamination is part of reducing reactions such as those used to degrade essential amino acids into nonessential amino acids, and is the primary step of amino acid metabolism. The metabolism of amino acids follows in two steps, a transamination reaction and an oxidative deamination reaction. Through this process, a

nitrogen group and carbon skeleton will be formed as a result. Depending on the needs of the cell, the nitrogen group can be excreted from the body or reused to help form another biological molecule, and the carbon skeleton can be formed into ATP.

Almost all essential amino acids undergo transamination as the first step of amino acid catabolism. Generally, alpha amino acids are metabolized by an accepting carrier molecule that takes the amine group. In almost all cases, the carrier molecule is alpha ketoglutarate. In this transfer, an alpha keto acid and glutamate are formed. The enzyme that catalyzes this reaction is aminotransferase, and is found in the cytosol and predominantly in the liver and muscle tissues.

The major types of aminotransferases are alanine aminotransferase and aspartate aminotransferase. In order for aminotransferases to function properly they require the assistance of coenzyme pyridoxal phosphate.

For the past seven decades aspartate aminotransferase has been the foundation for studying the mechanistic behaviors of pyridoxal phosphate. The catalytic behaviors in PLP dependent enzymes has been studied thoroughly due to its accessibility in chicken and stability. Due to manuscript, “Aspartate Aminotransferase: an old dog teaches new tricks” aspartate aminotransferase was studied to gain insight on how the protonation state influences the specificity and catalysis of PLP, the influence light has on the boundaries of AAT with PLP, and lastly the destabilization of the external aldimine intermediate in the mechanism of pyridoxal to pyridoxal phosphate.

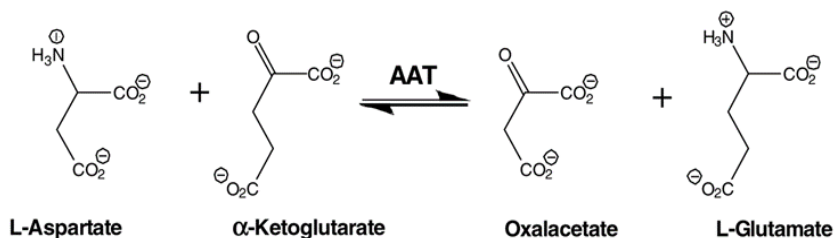


Fig. 3. Courtesy of manuscript, “Aspartate Aminotransferase: an old dog teaches new tricks” Overall mechanism for production of oxaloacetate and L-glutamate. Depending on the needs of the cell, the direction of the transamination mechanism is reversible.

Reaction Mechanism–

The overall reaction is shown in Figure 3 as aspartate and ketoglutarate are transformed into oxaloacetate and glutamate, this process is reversible. In this specific example of transamination L-aspartate behaves as the alpha amino acid providing the amino group for the transfer onto the alpha keto acid.

The first step of the mechanism is a nucleophilic attack from the active site of L-aspartate and proton transfer from the lysine residue present on pyridoxal phosphate. In the case of alanine aminotransferase, the free amino acid amine will attack the alpha carbon to eliminate the amino acid lysine, as well. Through rearrangement within pyridoxal phosphate, the lingering lysine is protonated helping form a quinoid intermediate (Schiff-base linkage). The Schiff-base alpha carbon is activated because of the behavior that nitrogen implements on the molecule. Alpha ketoglutarate attaches itself onto pyridoxal phosphate, and uses the lysine residue to eliminate the free amino acid. Pyridoxal phosphate becomes bound to the free amino acid and lysine residue.

All transferase enzymes behave the same, see figure 4 for a full better insight of the mechanism of aminotransferases. Along with aspartate aminotransferase, alanine aminotransferase is parallel in mechanistic behaviors, however it is the transfer of alanine and alpha ketoglutarate to pyruvate and glutamate.

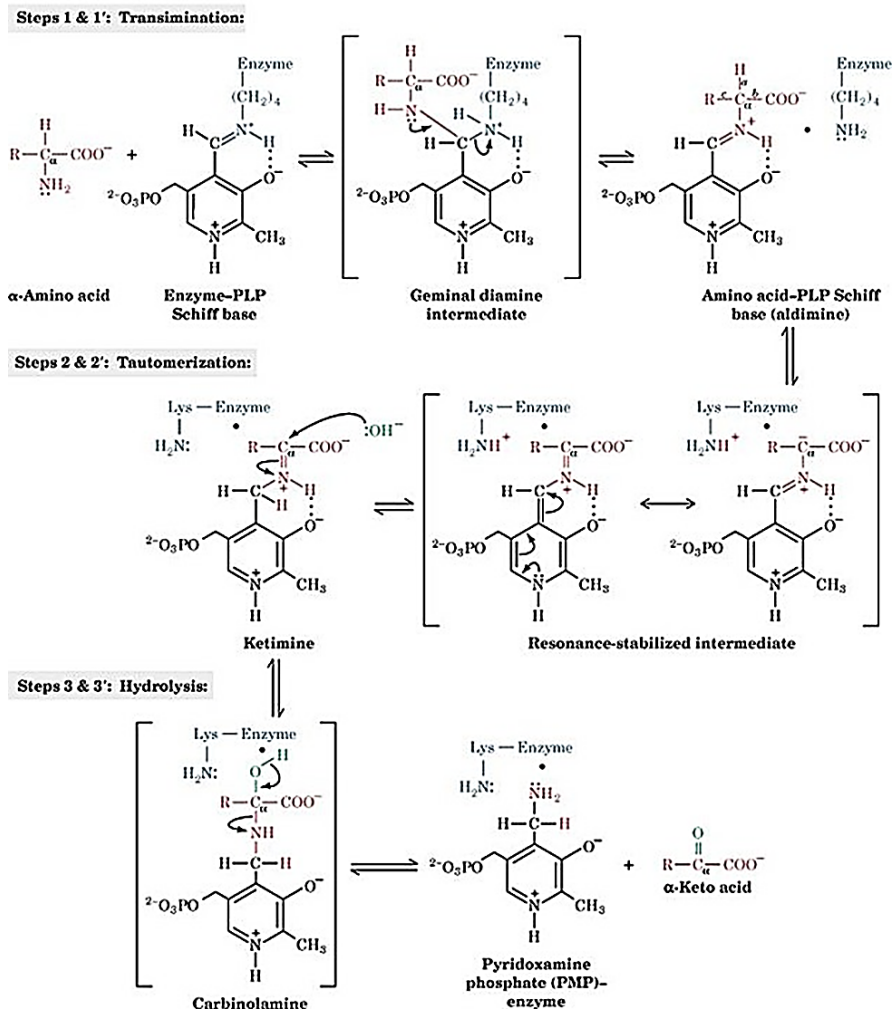


Fig. 4. Courtesy of Wikipedia Authors. Transamination. Wikipedia, The Free Encyclopedia 2019.

Creating Schiff Bases–

Pyridoxal forms a Schiff base linkage in every transaminase reaction, but why is that? Pyridoxal phosphate contains two major groups: a basic pyridine ring and an acidic hydroxyl group with the stabilization of a phenyl attached to it. This proves to say that pyridoxal phosphate is highly charged when the nitrogen group is

protonated and deprotonated. In these states, pyridoxal phosphate has stable tautomer forms. Although the nitrogen group is highly important for the stabilization of the molecule, the aldehydic group is by far the most important portion of PLP. In respect of the aldehyde group, PLP forms a covalent Schiff base linkage with amino acid substrates.

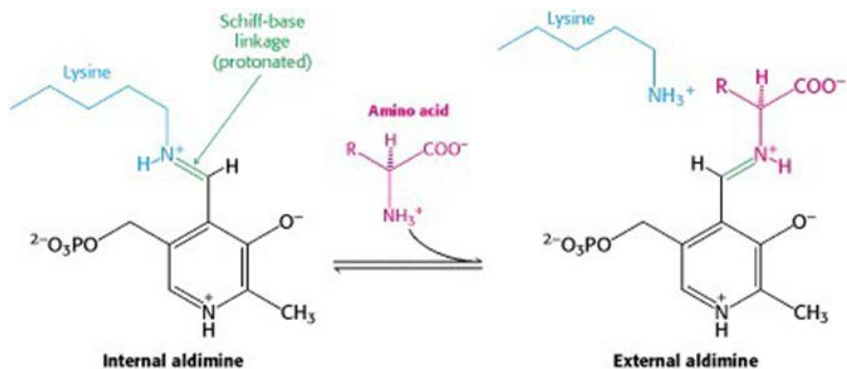


Fig. 5. Courtesy of J. M. Berg.; J. L. Tymoczko.; L. Stryer.; *Biochemistry*. 5th edition 2002. Transformation process of an internal aldimine to an external aldimine. Schiff base linkage between pyridoxal phosphate and amino acid substrate becomes tighter and more stabilized by noncovalent bonds.

The covalent Schiff base linkages are more often than not protonated and contain a positive charge due to the influence of the negativity of phenolate in PLP. The lysine residue is replaced by the alpha amino acid.

In summary, the internal aldimine soon transforms into an external aldimine. The covalent Schiff base interaction becomes an even stronger noncovalent bonded Schiff base interaction. In the Schiff base relationship between the pyridoxal phosphate structure and amino acid substrate, a quinoid structure is formed due to the loss of a proton. Soon after a ketimine molecule is produced. The result of a ketimine structure is the process of stabilization from a negative charge on the amino acid, and the protonation of the aldehyde group. The ketimine structure undergoes a process of hydrolyzation to produce another Vitamin B₆ derivative, pyridoxamine phosphate. (See figure 4). This

process of Schiff base protonation and deprotonation constitutes over half of transamination reactions.

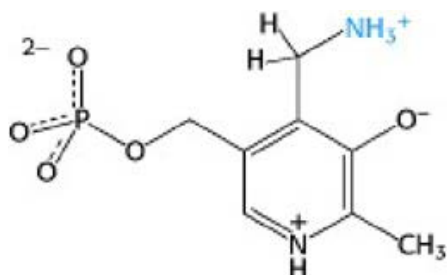


Fig. 6. Courtesy of J. M. Berg.; J. L. Tymoczko.; L. Stryer.; *Biochemistry*. 5th edition 2002. Pyridoxamine Phosphate (PMP). Result of hydrolyzation of ketimine structure in transamination reaction.

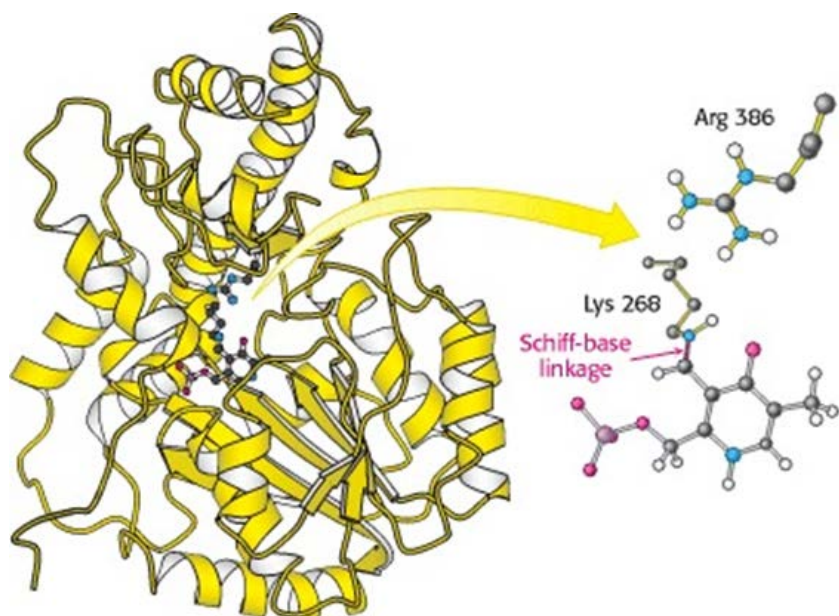


Fig. 7. Courtesy of J. M. Berg.; J. L. Tymoczko.; L. Stryer.; *Biochemistry*. 5th edition 2002. Example of x-ray data collected to study the catalytic behavior and mannerisms of PLP with substrates when bound together. Prototype of pyridoxal phosphate presenting a Schiff base linkage between a lysine amino acid and an active pyridoxal phosphate. The purpose of amino acid arginine is to assist the 3D fold structure of alpha carbons.

Decarboxylation

Another important enzymatic reaction that requires the presence of pyridoxal phosphate is decarboxylation. The overall outcome in this reaction is the removal of a carbonyl group and the loss of carbon dioxide. See figure 8. The reverse process of this reaction is widely known as the first step in photosynthesis. In biochemistry, pyridoxal phosphate promotes decarboxylation of all essential amino acids.

A imperative enzymatic reaction of decarboxylation is the step that binds glycolysis and the Krebs's cycle. This specific reaction is the decarboxylation of pyruvate. See figure 9. Glycolysis breaks down glucose into two pyruvate molecules. If oxygen is present then the cell can commit to cell respiration and transport two pyruvate molecules into the mitochondrial matrix. Once inside the mitochondrial matrix, the pyruvate molecule is oxidatively decarboxylated by a complex of proteins called the pyruvate dehydrogenase complex. This irreversible reaction involves another cofactor called coenzyme A that behaves like pyridoxal phosphate. Coenzyme A is a vital coenzyme as it is needed as a fuel source in the citric acid cycle, similar to how pyridoxal phosphate is needed to store energy and help the transformation of essential amino acids.

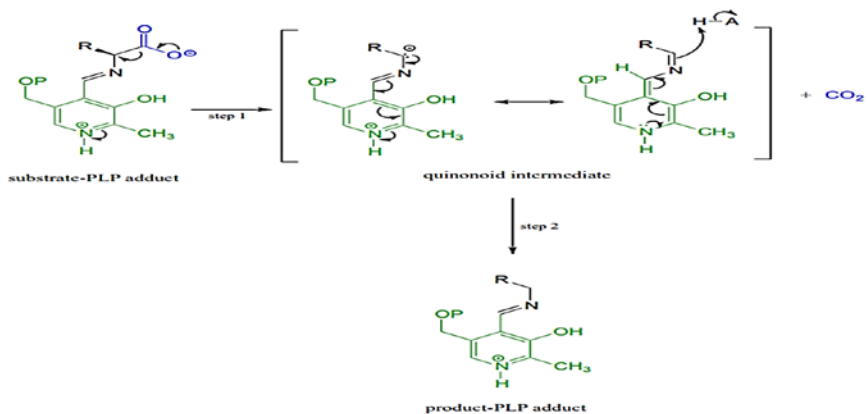


Fig. 8. Courtesy of T. Soderburg. Pyridoxal Phosphate (Vitamin B6). Chemistry LibreTexts 2019, 17.2. Overall mechanism for general decarboxylation.

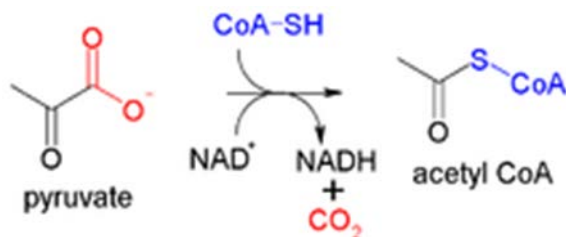


Fig. 9. Courtesy Wikipedia Authors. Pyruvate Decarboxylation. Wikipedia, The Free Encyclopedia 2019. The decarboxylation of pyruvate. This reaction involves another cofactor called coenzyme A as well as a NAD⁺ molecule. A single pyruvate reacts with coenzyme A and NAD⁺ to form acetyl coA, carbon dioxide, NADH, and a hydrogen ion.

Vitamin Deficiency

Over the past 50 years, the evolution of biotechnology for enzymatic treatment has greatly advanced. The Food and Drug Administration has also approved numerous types of anticancer, antioxidants, and has promoted the implication of enzymes in the body system. Pyridoxal Phosphate is present in over 150 enzymatic reactions within the body, and acts as an antioxidant molecule. Pyridoxal phosphate deficiencies have been connected to the root cause of a few diseases such as cancer and diabetes. Although the mechanisms to cancer and diabetes are unknown, evidence suggests that these diseases share the same risk factors.

Research in this field has been difficult due to the high cost of human studies and unavailability of controls. On the other hand, using mammals as study material cannot be done due to the incapability to synthesize pyridoxal phosphate (8). Mammals recycle pyridoxal phosphate through a salvage pathway of Vitamin B₆ from their nutritional intake, however, another organism was found to help promote this research. *Drosophila*, a fruit fly, was used to continue genetic studies due to its containment of large chromosomes. Within the chromosomes of *Drosophila* an encoded gene was found that presents PDXK enzyme, which is required for Vitamin B₆ biosynthesis. Mutations of this gene produce chromosome defects (CABS) which are then obtained by pyridoxal phosphate (8). Vitamin B₆

antagonists were also producing around the same frequencies confirming that PLP is a vital coenzyme in genome integrity.

There are instances where deficiencies in pyridoxal phosphate has been due to the incapability to produce liver cells, and others are caused by vices such as alcoholism. Deficiency of PLP has been influenced in countless disorders of the alcoholic patient such as convulsions, anemia and liver disease.

In 1974, two scientists tested the influence that alcoholism had on the deprivation of PLP on 66 male patients (7). These men were between the ages 18 and 68, and all had a record of chronic alcohol abuse, however, were restrained of any alcoholic beverage 5 days before the experiments were pursued. In assistance to the research, 94 healthy men volunteered to serve as comparison in the studies, but men taking any variety of supplement were disregarded. Plasma samples and erythrocytes were obtained and stored properly (7).

As a result of their findings, there is a high level of deranged PLP biosynthesis and is seen before any chronic liver disease. Over 50% of the abusive patients had PLP levels less than 5ng/mL in their plasma (7). Pyridoxal phosphate concentrations in plasma directly correlate with other biochemical indicators of the vitamin supplement. This confirms that the deficiency of PLP prevails in almost all abusive alcoholic patients. The job of PLP is to serve as a coenzyme in countless enzymatic reactions and metabolism of amino acids. In confirming that the recurring presence of alcohol alters the concentration of PLP, reversing the process will require intense vitamin supplements. Failure to correct the destruction of cells will more than likely lead to chronic tissue injury, if not death.

Summary

Vitamin B₆ is present in several forms, however, becomes mostly pyridoxal phosphate in its active form. PLP serves as a coenzyme in over 150 different enzymatic reactions, and countless metabolism reactions in our body. This coenzyme serves great purpose in assisting the stabilization of an amino acid

substrate by behaving as an electron sink in intermediates of enzymatic reactions. During transamination pyridoxal becomes pyridoxamine, another form of Vitamin B₆.

References

- (1) McCracken, J. Vitamin B₆ –What is it?. *No Excuses Health* 2013.
- (2) Toney, M. D. Aspartate Aminotransferase; an old dog teaches new tricks. *NIH Public Access* 2014, 119–127.
- (3) J. M, Berg.; J. L. Tymoczko.; L. Stryer. *Biochemistry*. 5th edition 2002.
- (4) J. Desai. Pyridoxal Kinase: It's role in Vitamin B₆ Metabolism. *VCU Scholars Compass* 2010, 1-51.
- (5) R. Percudani.; A. Peracchi. A Genomic Overview of Pyridoxal Phosphate Dependent Enzymes. *EMBO Reports University of Italy* 2003, Vol 4 NO 9.
- (6) G. M. Cooper. The Cell: A Molecular Approach. *Sinauer Associates, NCBI Bookshelf* 2000.
- (7) L. Lumeng.; T. Li. Vitamin B₆ Metabolism in Chronic Alcohol Abuse: Pyridoxal Phosphate and the Effects of Acetaldehyde on Pyridoxal Phosphate Synthesis and Degradation in Human Erythrocytes. *The Journal of Clinical Investigation* 1974, 693-704.
- (8) C. Meriglino.; E. Mascolo.; R. Burla.; I. Saggio.; F. Verni. The Relationship Between Vitamin B₆ and Cancer. *Frontiers in Genetics* 2018.
- (9) A. S. El-Sayed.; A. A. Shindia. PLP-Dependent Enzymes a Potent Therapeutic Approach for Cancer and Cardiovascular Diseases. *IntechOpen* 2011, NO 1-3.

A Constitutive Modeling of 3-D Printed PLA

Nicolas Fabbri

Mentor: Amber J. McClung, Ph.D.

St. Mary's University, San Antonio, TX

Most materials we use today in manufacturing and product development have very well documented mechanical properties. Metals in some shape, form, or fashion have been experimented with since thousands of years B.C. 3D printing and the thermoplastics that come with it are much newer materials, but we already use them in applications that range from water bottles to medical implants and drug delivery systems. Polylactic Acid (PLA) is a particularly interesting substance, being one of the few plant-based polymers that stands out among a field of oil-based substitutions. One of the main drawbacks of PLA, is the relative lack of study and agreed upon mechanical properties linked to the thermoplastic. Plastics in general do not react the same way more traditional materials do to the stresses that are applied to them. After a certain amount of stress, or under non-standard temperature conditions, plastics produce a viscoelastic response, which strays from a linear behavior that is seen at small loads. Several models are available to begin to capture this response in an accurate way. Among these are the Hookean Model, the Kelvin-Voigt Model, and the Maxwell Model. The Hookean Model is similar to a spring, and generates something similar to the linear response, but fails to capture the viscoelastic curve. The Kelvin-Voigt and Maxwell models incorporate dashpots, in an attempt to deal with the viscous behavior of the material. This paper takes pre-existing stress/strain data and applies these models in an attempt to see if they would fit the given tensile data.

I. INTRODUCTION

Polylactic Acid (PLA) as a material, is incredibly useful in a range of fields. From model prototyping to medical stents, PLA as a resource has a number of things that set it apart from other

materials that are used for roughly the same things. In terms of prototyping, PLA is one of the less expensive selections of thermoplastic, it can be made from discarded agricultural waste such as corn husk, and its natural alternative to the more prominent oil-based polymers available. In the medical field, specifically when manufacturing stents, PLA can generally replace the more traditional metal devices [1]. PLA's biological nature allows it to break down with time and in the long term, it leaves no trace in the natural tissue [2]. A recurring problem across all the fields in which PLA is used, is the relative lack of understanding of how PLA performs mechanically under various loading conditions.

For the majority of low-stress circumstances, PLA performs much like other solid materials, in a straightforward, linear matter. As PLA reaches higher stresses, or is exposed to smaller stresses over larger periods, it behaves in a viscoelastic manner [3]. A vast number of studies have aimed to characterize the way PLA performs under these long-term stress conditions [4]. Burger's Model and Maxwell's model are some of the generally accepted ways that capture the viscoelastic behavior. Other models, such as the Modified Three-Element Standard Solid Model combine Maxwell's model with linear elastic models in order to encompass the range of behaviors PLA expresses [5]. This study will focus on monotonic tension to failure of PLA taking pre-existing tensile data [6] and using a Hookean, Maxwell, and Kelvin-Voigt model to see how closely each model approximates the experimental data.

II. METHODOLOGY

The non-viscoelastic portion of PLA's tensile data is best approximated in a similar way to the more classic metals and other similar materials. In this paper we will compare the experimental PLA behavior to the predictions that several models produce. The description of the models are as follows.

Hookean Model

The Hookean is the simplest model, using a single linear spring element shown in Figure 1. This model accounts for the classic Hooke's Law, but instead of using a spring constant and displacement, the model approximates the response of PLA by using elastic stress (σ_e) and elastic strain (ϵ_e).

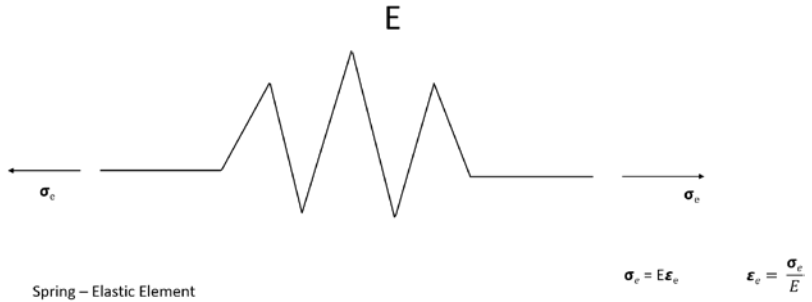


Figure 1: Spring Element

Elastic stress, elastic strain, and the modulus of elasticity (E) follow the simple linear model of Hooke’s Equation. Stress can be found by multiplying the constant modulus by the changing strain. Inversely, if stress is the known variable, strain can be found by dividing stress by the modulus.

The spring element in Figure 1 is often used in combination with a dashpot to create more sophisticated material models. The dashpot is conveyed in Figure 2 and represents a viscous fluid. Viscosity can be described as a fluid’s resistance to flow. This also encompasses how well fluids can pass through the host fluid, which is the main focus of the dashpot model. If we take water as an example objects dropped into water sink through it quite easily as long as the density is less. However, dropping a similar object into a viscous fluid would result in the object coming to a stop much further from the bottom, as a result of the fluids internal resistance. By repeating a motion in a viscous fluid, motion can be brought to a halt gradually. This is known as a dampening effect. The dashpot model aims to characterize that damping motion.

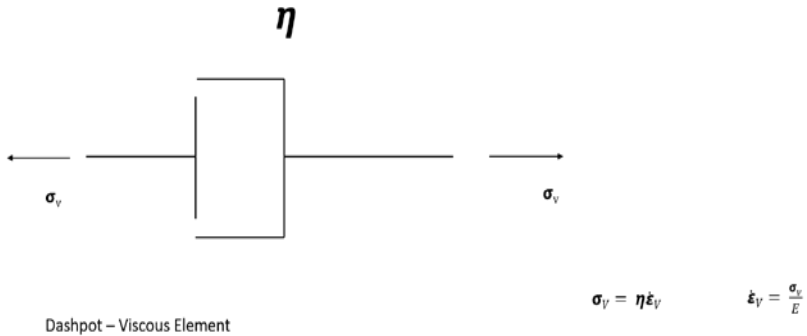
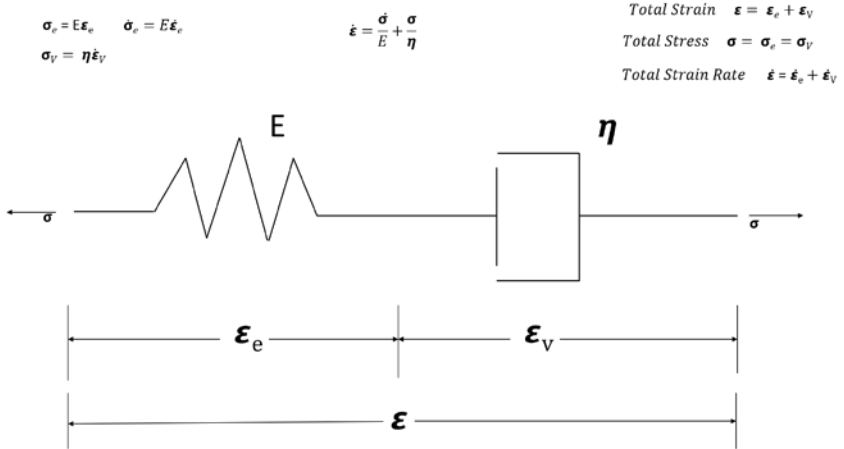


Figure 2: Dashpot element

Like Figure 1, the variables shown in the dashpot model follow a simple linear pattern. However, the variables used in this equation are much different. The stress of the viscous model must be found by taking into account the viscosity constant (η) multiplied by the strain over time ($\dot{\epsilon}$). Viscous strain ($\dot{\epsilon}$) is similar to elastic strain separated only by the portion of a stress/strain graph the particular strain can be found on. Strain rate is simply taking that strain and dividing by the time constant used when finding the variables themselves.

Maxwell Model

The Maxwell model shown in Figure 3 goes one step further than the Hookean Model. By combining both the dashpot and spring element, this model attempts to capture elements of both the solid and viscous portions of PLA's tensile curve.



The Maxwell Model simply puts the dashpot and spring elements into series, which means the equations are fairly similar. The total of stresses (σ) and strains (ϵ) can be found by adding the elastic portion of the data and the viscous portion of the data, which again is determined by which portion of the stress/strain graph the data can be found on. Total strain rate ($\dot{\epsilon}$) is the addition of both viscous and elastic strain rates. Elastic stress rate ($\dot{\sigma}_e$) is found by taking into account the time period the data is collected over, much like strain rate from Figure 2. The total strain rate ($\dot{\epsilon}$) for the Maxwell Equation is the only outlier, having to add elastic stress rate divided by modulus and viscous stress divided by the viscosity constant.

Kelvin – Voigt

The Kelvin-Voigt model shown in Figure 4 takes a similar approach to the Maxwell Model, by combining the two single element models, but instead of combining them in series, it attaches them in parallel.

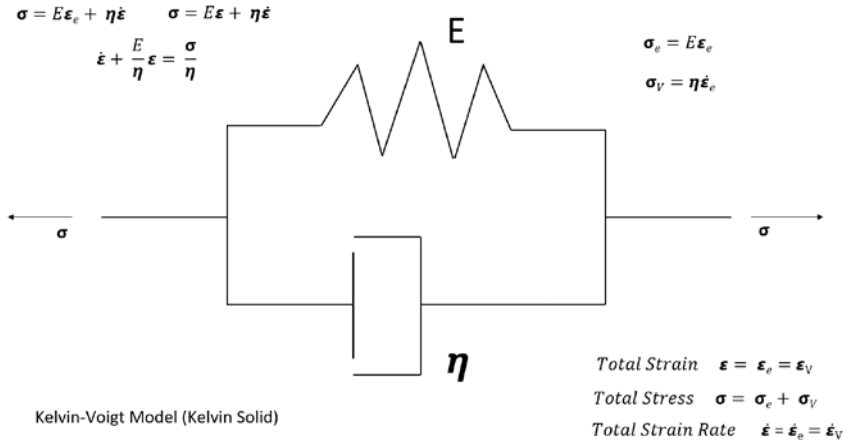


Figure 4: Kelvin Solid

Total strain, total stress, and total strain rate are all outlined in Figure 4. Respective stresses in this model are calculated by multiplying the modulus by their strains and adding the viscosity constant by their strain rates. The model itself adds strain rate to modulus divided by viscosity multiplied by basic strain. This can be simplified by using the stress equations to get stress divided by the viscosity constant.

III. MODELING RESULTS

In this section, the results of the numerical predictions of the three models are compared to monotonic tension to failure of PLA [6].

Hooke's Law

The linear formula of the Hookean Model approximates the way that the elastic portion of the data reacts to the strain very well. However, once Figure 5 reaches the viscous portion and deviates from that pattern, the model fails to address the decrease in stress the material experiences. Since this model uses the Modulus of elasticity as the unchanging constant, this outcome is expected, since the elasticity of plastics has a higher tendency to change under varying amounts of deformation. As the material necks the stress cannot increase with strain, this model cannot account for those changes.

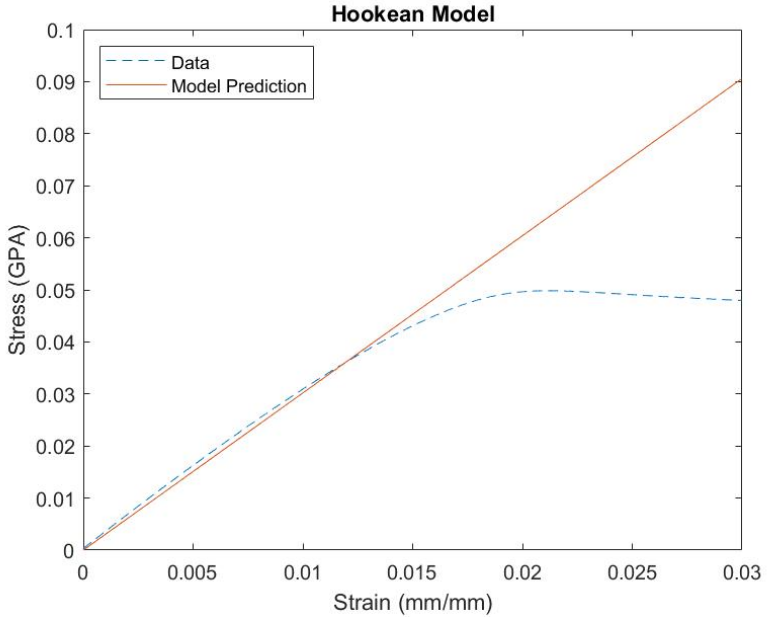


Figure 5: Hook's Law Data

Maxwell Model

The Maxwell model is different from the Hookean model, in that the slope relies heavily on the viscosity constant. Using a simple backward finite difference method to calculate the stress rate, the Maxwell model curve ends up with an overall noisy appearance due to the incorporation of rates into the equations. The stress and the strain rate are calculated from the experimental data, so with the simple finite difference method, the normal noise in the measured signal is creating noise in the resulting calculated model. Increasing the velocity constant, as seen in Figure 7 and Figure 8, does little to nothing to match the model to the data.

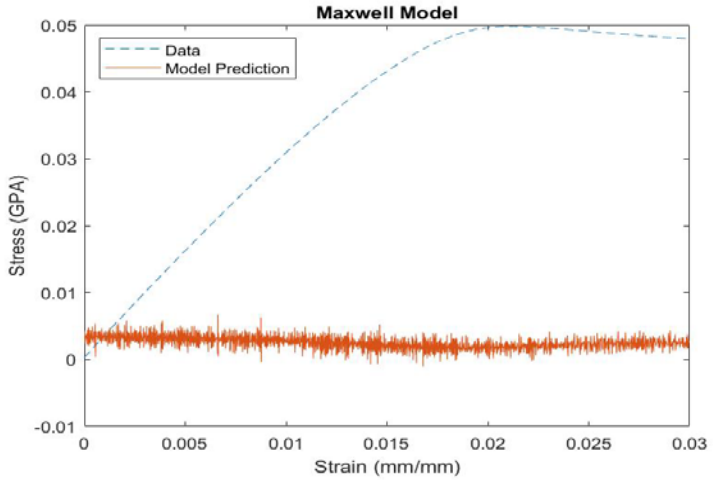


Figure 6: Maxwell Model Data

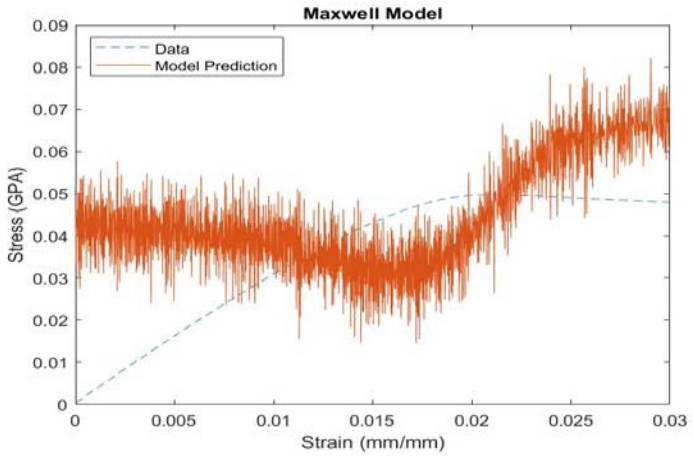


Figure 7: Maxwell 20 Viscosity

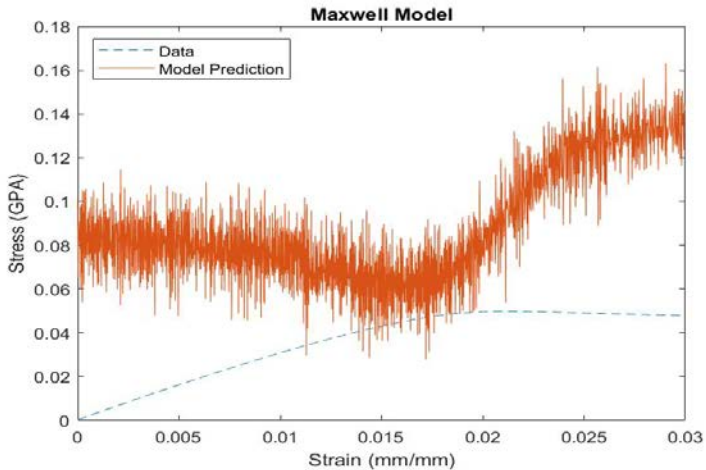


Figure 8: Maxwell 50 Viscosity

This model still shows theoretical promise in matching the experimental data. However, more sophisticated numerical methods must be implemented to effectively utilize this model.

IV. KELVIN-VOIGT MODEL

The results comparing the Kelvin-Voigt with the data are shown in Figure 9. The major difference in this model from the Hookean is that this model relies primarily on changing strain rate instead of the engineering strain value. The averaging effect of the varying strain rate actually provides what seems like a better model, actually seeming to follow the data curve more closely than the Hookean model, minus the slight deviation in starting point. Both models still fail to account for any viscoelastic behavior of the PLA at higher stresses.

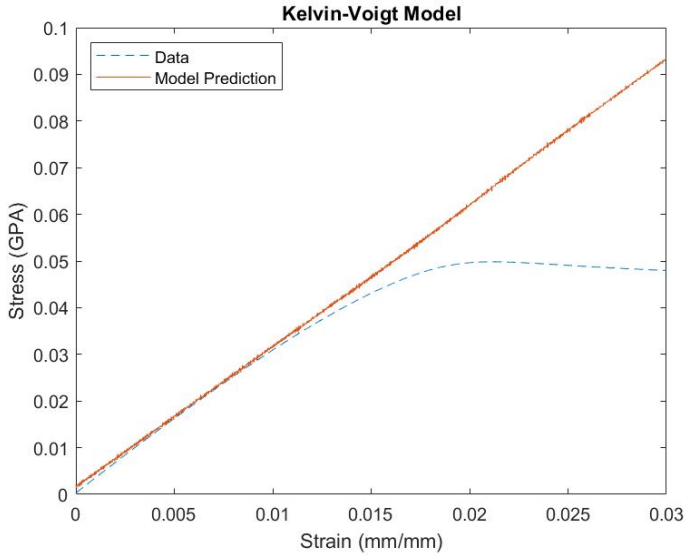


Figure 9: Kelvin-Voigt Model Data

V. CONCLUDING REMARKS

Overall, it seems that all three models evaluated lack the ability to follow the viscoelastic behavior of PLA for the entire tension to failure curve when implemented with a simple finite difference numerical method. Both the Hookean and Kelvin-Voigt models followed the linear portion of the curve adequately but fell apart as the predictable elastic behavior of the material faded.

As for the “noise” in the Maxwell models, the numerical approaches taken in this study, while appropriate for a first attempt at modeling, show obvious shortcomings in the results. These shortcomings are numerical method shortcomings and do not necessarily reflect the ability of the theoretical model to predict the material behavior. Future work aims not only to identify and test more models, but to refine the capabilities of the numerical methods implemented to better capture the ways the models are intended to work. For example, the central difference method relies on forward data points in addition to backwards data points from the backwards difference method. These averages may very well smooth out the data.

VI. ACKNOWLEDGEMENTS

I would like to thank the St. Mary's University Department of Engineering for the opportunity to work with equipment, resources and faculty I would not have had the chance to work with had everyone involved not worked incredibly hard towards continued education of future engineers. I would also like to give a sincere thank you to Dr. Amber McClung for her continued guidance and encouragement throughout this summer research project as well as the other research projects I have had the pleasure of being able to work with her on as well as her guidance through my educational journey and all the help she's given me concerning my future career and educational goals. And of course, a big thank you to the Ronald E. McNair Scholars Program for the opportunity to do research this summer as well as the members of the St. Mary's University McNair Scholars staff to all the guidance and support they have given me in my journey to acquire a PhD.

REFERENCES

- [1] K. V. Niaza, F. S. Senatov, A. S. Stepashkin, N. Y. Anisimova and M. V. Kiselevsky, "Long-Term Creep and Impact Strength of Biocompatible 3D-Printed PLA-Based Scaffolds," *Nano Hybrids and Composites*, vol. 13, no. 1, p. 15, 2017.
- [2] J. S. Bergstrom and D. Hayman, "An Overview of Mechanical Properties and Material Modeling of Polylactide (PLA) for Medical Applications," *Annals of Biomedical Engineering*, vol. 44, no. 2, pp. 330-340, 2016.
- [3] L. Rozite, J. Varna, R. Joffe and A. Pupurs, "Nonlinear behavior of PLA and lignin-based flax composites subjected to tensile loading," *Journal of Thermoplastic Composite Materials*, vol. 26, no. 4, pp. 476-496, 2013.
- [4] C. Martins, V. Pinto, R. M. Guedes and A. T. Marques, "Creep and Stress Relaxation Behavior of PLA-PCL Fibres - A Linear Modeling Approach," *Procedia Engineering*, no. 114, pp. 768-775, 2015.
- [5] R. M. Guedes, A. Singh and V. Pinto, "Viscoelastic modelling of creep and stress relaxation behavior in PLA-PCL fibers," *Fibers and Polymers*, vol. 12, 2017.

- [6] J. Torres, O. Onwuzurike, A. J. McClung and J. D. Ocampo, "Influence of an extreme on the tensile mechanical properties of a 3D printed thermoplastic polymer, extended abstract," in *Society for Experimental Mechanics*, Greenville SC, 2018.
- [7] A. C. Vieira, A. T. Marques, R. M. Guedes and V. Tita, "Material model proposal for biodegradable materials," *Procedia Engineering*, vol. 10, pp. 1597-1602, 2011.
- [8] M. Morreale, M. C. Mistretta and V. Fiore, "Creep Behavior of Ploy(lactic acid) Based Biocomposites," *Materials*, vol. 10, no. 4, pp. 1944-1996, 2017.

Painting the sky blue: Comparing the Policies, Plans, and Regulations to Reduce Air Pollution in Beijing and Mexico City

Regina de la Parra

Mentor: Aaron Moreno, Ph.D.

St. Mary's University, San Antonio, TX

Outdoor air pollution, also known as one of the silent killers, is a global issue affecting the lives of millions of people. There are many causes of air pollution, with data showing man-made sources as the leading producers. Yearly, more than 7 million people around the world die due to air pollution. From these 7 million people, 2 million are located in the Western Pacific Region and 1 million in the Africa region. While there is a lot of information available, there is currently a lack of research that compiles and compares information from various nations, including independent, comprehensive studies on the regulations and rate of success of nations such as those done regarding “blue sky days” in Beijing, China. While many nations handle air pollution in a similar way, some countries are better than others at regulating air pollution. This is supported by the fact that many cities within the same region have better air quality than others, as well as the fact some nations are better at implementing policies and regulations, and nations with a long history of air pollution know which practices work best when reducing this. By analyzing the Mexico City Metropolitan Area and the Beijing Metropolitan Area, this paper will compare the success of their policies that seek to reduce air pollution as well as understand which of these similar policies, regulations and practices work best. Lastly, this report will provide a comprehensive summary of these regulations which will serve as a guide for individuals, local governments and nations.

Introduction

According to the National Institute of Environmental Health Sciences (NIH), air pollution is a mixture of natural and man-made substances in the air we breathe. This type of pollution is divided into two categories: indoor air pollution and outdoor air pollution.¹ Both indoor and outdoor air includes the exposure to a variety of contaminants, including exposures to particulates, carbon oxides, noxious gases such as sulfur dioxide, carbon monoxide, chemical vapors, etc., as well as mold and pollen, household products and chemicals, and other substances. Since the beginning of the Industrial Revolution during the 1800s, the presence of air pollution has increased, as well as the problems associated with it.²

Air pollution is a problem that is recognized around the world by experts and organizations because of its impact on human health and the environment. According to the United Nation Special Rapporteur’s report, every year, about 7 million premature deaths in the world are caused by ambient and household air pollution, including the deaths of more than 600,000 children.³ Furthermore, this “silent killer” disturbs the lives of millions of animal and plant species and their environments. Since its upsurge during and after the Industrial

¹Meredith McCormack, “Air Pollution,” Government, National Institute of Environmental Health Sciences, February 11, 2020, <https://www.niehs.nih.gov/health/topics/agents/air-pollution/index.cfm.1/6/2021 10:55:00 AM>

² History.com Editors, “Water and Air Pollution,” Informative, HISTORY, November 6, 2009, <https://www.history.com/topics/natural-disasters-and-environment/water-and-air-pollution>.

³ *Report of the Special Rapporteur on the Issue of Human Rights Obligations Relating to the Enjoyment of a Safe, Clean, Healthy and Sustainable Environment, 2016, Human Rights and the United States: Chapters 15-23 and Appendixes*, 2017, <http://blume.stmarytx.edu:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=edsgvr&AN=edsgcl.7171000300&site=eds-live&scope=site>.

Revolution, nations began to acknowledge the problems that this issue was causing and began to try and limit these problems. Despite this, local and international governments still struggle in their effort to reduce air pollution, and the hazardous impacts it creates.

Air pollution happens on a global scale and in developing countries, pollution tends to increase with per capita income. This is usually driven by the increase of manufacturing output and demand for services, such as private transport and electricity.⁴ Developing countries are often associated with a weaker institutional setting incapable of creating and enforcing strong environmental regulations, which in turn, enhances the problem and increase of air pollution. But as mentioned before, air pollution is a worldwide problem, and its highest levels are located at megacities in almost every continent of the world. According to the World Urbanization Prospects, megacities are defined as urban agglomerations of more than 10 million people. In 2014, 28 megacities existed in the world, with a total of 453 million people. Additionally, the 30 most populated urban areas account for 7% of the global burden that air pollution causes, with some megacities in East and South Asia having higher per capita effects.⁵ While the majority of these cities and their respective governments have policies and regulations that guide citizens and companies on their emissions of air pollutants, many still struggle with the battle of air pollution, including with negligence and temporary fixes to this problem.

For example, Chinese cities have seen drastic changes in the air quality, ranging from clear skies, to days of extreme air pollution, creating international concern. The People's Republic of China has a long history of addressing air pollution through regulations and policies that affect the areas of manufacturing and movement of vehicles. An increase of efforts to reduce the

⁴ Miriam E. Marlier et al., "Extreme Air Pollution in Global Megacities," *Current Climate Change Reports* 2, no. 1 (2016): 15, <https://doi.org/10.1007/s40641-016-0032-z>.

⁵ Miriam E. Marlier et al, 2016.

amount of air pollution in China date back to February 1998, when Beijing launched the campaign ‘Defending the Blue Sky’. As part of this campaign, daily and yearly air quality data was collected and shared with the people, allowing them to have some information about the pollution in the air and to rank better than third place in a list of 145 cities with the most air pollution in the world.⁶ More recently, in 2014, Li Keqiang, Prime Minister of China, declared ‘war against environmental pollution’ and promised to impose heavier punishments to cut the toxic smog.⁷ Strong and soft regulations such as halting of industry, reduction of traffic, and the creation of national holidays have all been created to reduce the amount of smog and other pollutants in the air for a short period of time.

In this paper, two metropolises will be discussed, Beijing and Mexico City metropolis, in order to understand different methods of pollution regulation and how successful these are in relation to a successful reduction of air pollution. Additionally, by analyzing regulations that are similar between cities, or that seek to reduce air pollution in a similar way, we will further understand where these regulations work best and the reasons behind this. For this paper, the areas selected vary in geographic location, governmental leadership, economy, and other factors that affect and can potentially affect the amount and types of air pollution. The differences that these cities have allow us to comparable to each other to understand how these differences affect the city’s air pollution and the things they can learn from each other.

Beijing, China

Beijing is located in the north part of China and it is the nation’s capital and covers an area of 16,400 square kilometers. It is located 70 miles from the Bohai Sea, making it relatively close to shore. Being the capital, it is a metropolis and major

⁶ Andrews SQ. Inconsistencies in air quality metrics: ‘Blue Sky’ days and PM10 concentrations in Beijing.

⁷ Brimblecombe P, Zong H. Citizen perception of APEC blue and air pollution management. Atmospheric Environment.

transportation hub. Additionally, it is considered the political, educational, and cultural center of China.⁸ With more than 20 million people, Beijing is one of the cities in the world with the most air pollution and it has been struggling with this issue for a long time. In 1998, the majority of air pollution in Beijing was due to coal-combustion and motor vehicles.⁹ Compared with 20 years earlier, China experienced a sharp increase on its GDP, population, and vehicles by 1078%, 74% and 335% respectively at the end of 2017 (Figure 1).¹⁰ The country as a whole was experiencing a rapid growth in the developing world, which in turn increased the deterioration of its environment. This caused negative effects to the health of its population which inspired a comprehensive air pollution control program to reduce air pollution.

The first local efforts to reduce air pollution included pollution control measures at the industrial level, more specifically, “end-of-pipe” treatments which process waste before being discharged into the environment. Later in 1998, the Beijing Municipal Government published the Announcement of Urgent Measures to Control Air Pollution of People’s Government of Beijing Municipality, making it the first declaration in China on air pollution control. Essentially, the document declares war to air pollution.¹¹ The following years continued to successfully reduce air pollution through measures that targeted particulate matter (PM_{2.5}), dust, and soot.

⁸ Travel China Guide. “Beijing Facts: Introduction, Location, History, Districts, Attractions,” September 30, 2019.

<https://www.travelchinaguide.com/cityguides/beijing/>.

⁹ UN Environment 2019. A Review of 20 Years’ Air Pollution Control in Beijing. United Nations Environment Programme, Nairobi, Kenya

<https://www.unenvironment.org/news-and-stories/press-release/beijing-air-improvements-provide-model-other-cities>

¹⁰ UN Environment, 2019

¹¹ UN Environment, 2019

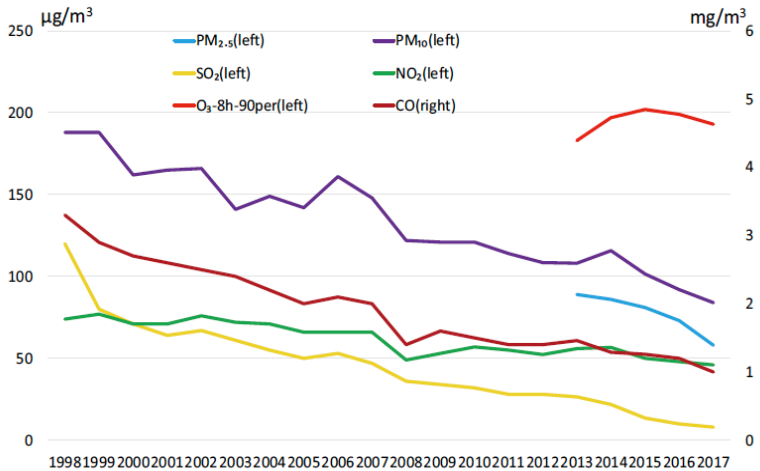


Figure 1. Changes in annual average concentrations of air pollutants in Beijing, 1998-2017

Source: Former Beijing Municipal Environmental Protection Bureau through the United Nations

In 2008, the 29th Summer Olympic Games served as an opportunity to improve air quality and accelerate the implementation of more stringent measures. These were so successful, that air pollution decreased to the lowest level one month before and after de games.¹² Just months after the Olympics, the capital of China later saw an increase of air pollution, and it went back to being one of the most polluted cities in the world. In 2011, the US Embassy in Beijing revealed data indicating that the PM_{2.5} concentration in the capital was beyond index when compared to the United States Environmental

¹² Wang, Li, Fengying Zhang, Eva Pilot, Jie Yu, Chengjing Nie, Jennifer Holdaway, Linsheng Yang, et al. “Taking Action on Air Pollution Control in the Beijing-Tianjin-Hebei (BTH) Region: Progress, Challenges and Opportunities.” *International Journal of Environmental Research and Public Health* 15, no. 2 (February 2018). <https://doi.org/10.3390/ijerph15020306>.

Protection Agency (US EPA's) air quality index.¹³ This raised international and national concern about severe air pollution in China, raising government and public awareness of the need for more stringent regulations. These included targeting primary pollutants such as Sulfur Dioxide (SO₂), Nitrogen Dioxide (NO₂), PM₁₀, and Carbon Monoxide (CO) in the industrial level and local level, including the reduction of traffic, as well as the installation of low-NO_x gas-fired boilers in residential homes and buildings.¹⁴ Additionally, many industries were moved from Beijing into its surroundings. This decision helped the Beijing area to lower its air pollution levels, but increased the surrounding's levels, including the Beijing-Taijin-Hebei area.¹⁵

After 2013, secondary air pollutants received the most attention, including PM_{2.5}, the most dangerous kind of air pollution, which is carried deep into your lungs and then your bloodstream¹⁶. A threshold of this pollutant was added to China's Ambient Air Quality Standards, and other pollutant's limits were tightened. Later that year, Beijing revealed the Beijing Clean Air Action Plan, which focused to control PM_{2.5} pollution to protect public health during a period of five years. By the end of 2017, according to data collected by Beijing officials, the annual average PM_{2.5} decreased to 58µg/m₃ from 89.5µg/m₃ in 2013.¹⁷

Policies and Regulations in Beijing

For the past 22 years, Beijing has implemented a number of policies and regulations that seek to decrease air pollution in the city. Some of these include economic incentive policies, which provide financial support to implement pollution control measures in various pollution sources. This financial support is

¹³ Wang, Li et al, 2018

¹⁴ UN Environment, 2019

¹⁵ Wang, Li et al, 2018

¹⁶ Pasick, Adam. 2014. "Beijing Broke Its Own Air-Quality Rules and Held a Marathon in Toxic Conditions." Quartz. October 20, 2014.

<https://qz.com/283665/beijing-broke-its-own-air-quality-rules-and-held-a-marathon-in-toxic-conditions/>.

¹⁷ UN Environment, 2019

used to subsidize clean energy renovation of coal-fired boilers, coal-to-electricity heating renovation for urban bungalows, the purchase of new energy vehicles, retrofitting heavy-duty diesel vehicles, etc. In the nation, one of the most important pieces of regulations is the Constitution of 1982. Article 26 provides that the state protects and improves the environment and prevents and controls environmental pollution and other public hazards.

Additionally, it dictates that the state organizes and encourages the protection of forests¹⁸. One would expect that this article explains more in detail how are states supposed to fulfill this, but the article does not provide any other information, let alone, any clear information as to how local governments should behave.

Another national law is the Air Pollution Prevention and Control Law, which regulates various sources of air pollution, including coal combustion, motor vehicles and vessels, etc. Also known as the New Air Act of 2015, it requires cities to release and submit definitive plans to make sure they are on track to meet national air quality targets. It is the first law to mention the need to control greenhouse gases and addressing sources from coal. This is known as one of the most stringent plans to date since it does hold accountable local governments so that they make concrete plans to meet air quality targets and it encourages public input. This is a five-year plan, and there's one for the three megapolises. The Beijing-Tianjin-Hebei regions is the area with the most stringent plan of all since it is regarded as the area with the most air pollution.¹⁹ Although this plan is very complete and includes information for many levels, there were still some problems associated with it. One of these issues lays with the

¹⁸ *China. Constitution of the People's Republic of China, Adopted on September 20, 1954 by the First National People's Congress of the People's Republic of China at Its First Session. [Rev. Translation]. Peking: Foreign Languages Press, 1961.*

¹⁹ Wang, Li, et al. 2018. "Taking Action on Air Pollution Control in the Beijing-Tianjin-Hebei (BTH) Region: Progress, Challenges and Opportunities." *International Journal of Environmental Research and Public Health* 15 (2). <https://doi.org/10.3390/ijerph15020306>.

management and supervision of the process. According to researcher Wang, there are still companies violating pollution emission standards. In addition, some companies evaded routine government inspections.²⁰

The plan also includes traffic restrictions and other proposals to reduce traffic emissions. After analyzing the effects of these regulations, it was found that the major challenges during the implementation of it were related to the ability to identify and control trucks and service vehicles that exceed emission standards.²¹ Today, despite the efforts to eliminate air pollution, Beijing still fails to meet the national standards for multiple pollutants, including PM_{2.5}, NO₂, and PM₁₀ during autumn and winter and Ozone pollution during the summertime.²²

Mexico City

Mexico City is the capital of Mexico, and it is one of the oldest continuously inhabited urban settlements in the Western Hemisphere and one of the world's most populous metropolitan areas.²³ The capital is located along the banks of a river and it lies in a inland basing called the Valley of Mexico. The term Mexico City can also be applied to the capital's metropolitan area, extending to the Estado of Mexico. Its population is very large, totaling to about 8.8 million people in the city and 20 million in the Mexico City Metropolitan Area (MCMA). Because of this, the city can be compared to other populous cities such as New York City and Los Angeles, but the main difference is the geographic size of the city, since it's area totals to just 1,485 km² (Figure 2).

²⁰ Wang, Li, et al. 2018. "Taking Action on Air Pollution Control in the Beijing-Tianjin-Hebei (BTH) Region: Progress, Challenges and Opportunities." 2018

²¹ Wang, Li, et al. 2018. "Taking Action on Air Pollution Control in the Beijing-Tianjin-Hebei (BTH) Region: Progress, Challenges and Opportunities." 2018

²² UN Environment, 2019

²³ Carlos Rincón Mautner. 2019. "Mexico City." Encyclopedia Britannica. January 9, 2019. <https://www.britannica.com/place/Mexico-City>.

Mexico City has battled with air pollution for a long time. In 1992, the United Nations named it the most polluted city in the world, and only six years later, it was named as the most dangerous city in the world for children.²⁴ This environmental problem has several causes. One is explained with its geographical location and topography. The metropolitan area has an average altitude of 2240 m over sea-level and it is surrounded by mountains. Its location in the world gives this area two main seasons, dry weather from the months of November to April, and wet weather from May to October.²⁵ There are many factors that affect the climate in the MCMA, making it more complicated than it is expressed here. Additionally, because of the mountains, there is not a lot of air flow, causing fog and air pollution to remain stagnant and accumulate. Studies about air flow and wind movement have done for the last three decades, which allow us to deeper understand how pollutants behave with wind movement.²⁶

²⁴ Hibler, M. 2004. "Taking Control of Air Pollution in Mexico City." *IDRC - International Development Research Centre*, June. <http://hdl.handle.net/10625/29264>.

²⁵ Salcido, Alejandro, Susana Carreón-Sierra, and Ana-Teresa Celada-Murillo. 2019. "Air Pollution Flow Patterns in the Mexico City Region." *Climate* 7 (11). <https://doi.org/10.3390/cli7110128>.

²⁶ Salcido et al, 2019

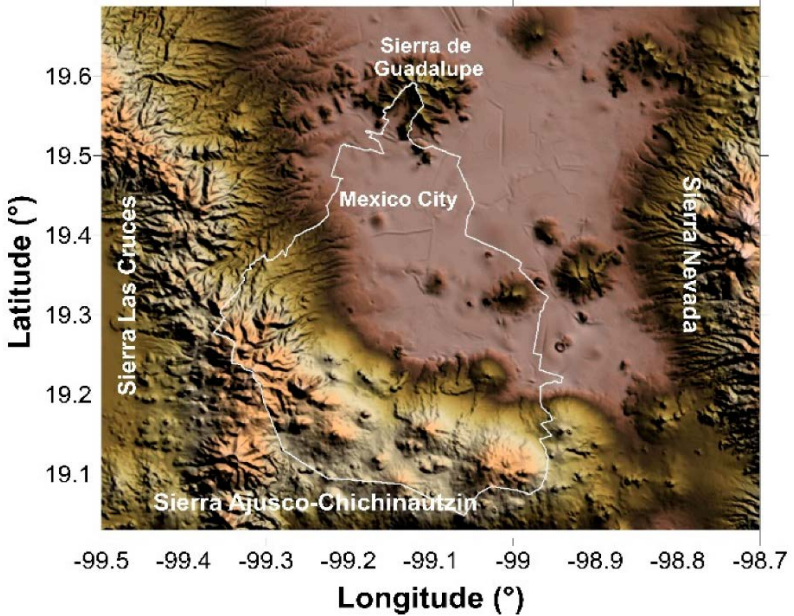


Figure 2. Topography in Mexico City Metropolitan Area (MCMA).
 Courtesy of MDPI, <https://www.mdpi.com/2225-1154/7/11/128/htm#cite>

Another factor is that affects air pollution in Mexico City is the amount of people in comparison with the area of the MCMA. With more than 20 million people, there is a lot of air pollutants being emitted on a daily basis. Mexico City's air pollutants are ozone (O_3), sulfur dioxide (SO_2), precursors like nitrogen oxides (NO_x), hydrocarbons (HC), and carbon monoxide (CO), that originate from the incomplete combustion of fossil fuels.²⁷ These, combined with the low amounts of oxygen that high altitudes cause, makes fossil fuel combustion far from ideal. With more than 3 million cars in the MCMA, vehicles are the leading source of air pollution.²⁸

²⁷ Maricela Yip, and Pierre Madl. 2000. "Air Pollution in Mexico City." December 14, 2000. <https://biophysics.sbg.ac.at/mexico/air.htm>.

²⁸ Maricela et al, 2000.

Policies and Regulations in Mexico City

The importance to reduce air pollution in the MCMA has been a priority for Mexico's Metropolitan Environmental Commission since the 1990s. At that time, for instance, the government introduced two air quality improvement programs, the Comprehensive Program Against Air Pollution (PIICA) and the ProAire (which means Pro-Air in English). Both aimed to improve air pollution by focusing in various areas, including reduction of energy consumption, cleaner and more efficient energy across all sectors, environmental education, and others.²⁹ Additionally, specific actions to remove lead from gasoline and implement catalytic converters in automobiles helped reduce some pollutants in the air.³⁰ The government of Mexico also strengthened the vehicle inspection, as well as their maintenance. When the ProAire program ended in 2000, environmental authorities created a longer and firmer air quality program, ProAire 2000-2010.³¹ Additionally, the city promoted in 2008 the program "Hoy No Circula", which restricts the movement of cars in order to control and reduce the air pollution levels.³² Despite the number of regulations implemented in the area, the levels of air pollution continue to be very high. For example, researchers show that there is little to no evidence that the "Hoy No Circula" program has actually made any improvements reducing air

²⁹ CPI. 2016. "Mexico City's ProAire Program." Centre for Public Impact (CPI). February 26, 2016. <https://www.centreforpublicimpact.org/case-study/mexico-citys-proaire-program/>.

³⁰ Molina, L., Benjamin de Foy, O. Vazquez-Martinez, and Víctor-Hugo Páramo. 2009. "Air Quality, Weather and Climate in Mexico City" 58 (January): 48–53. https://www.researchgate.net/publication/292248879_Air_quality_weather_and_climate_in_Mexico_City

³¹ Hibler, 2014

³² Gobierno de Mexico. 2018. "Hoy No Circula." Hoy No Circula. 2018. <https://www.hoy-no-circula.com.mx/>.

pollution despite its aim to reduce it about 15%.³³ In addition, as in Beijing, many trucks and service vehicles are not regulated yet. Mexico's *colectivos* (minibuses that are used to transport about 60 passengers) were implemented to reduce the use of vehicles and to provide a faster service for a short distance than the metro. The issue is that these vehicles are getting old, polluting the air more than more modern options. The ProAire program fails to check these vehicles to be compliant, as well as private owned cars known as *chuecos*, or those that have their plate changed illegally or manipulated to show lower emission levels.³⁴

Another effort by the Mexico City local government was the making of the Metropolitan Environmental Commission. Created in 1996, its job is to coordinate the policies and programs that are implemented in the metropolitan area. The program also takes part in educating the public, as well as creating open conversations with elected officials and members of the public. Although the work of this commission is very important to the metropolitan area, the commission does not have a specific budget provided by the local government.³⁵ This is due to Mexico's change of Presidency and local management every six years. With a new presidency, new elected officials are appointed to the offices, changing the direction of the plans and affecting the continuity of these. This makes the commission lack a defined operative organizational structure. One solution to this could be have a non-partisan team that is able to efficiently manage the

³³ Davis, Lucas W. 2017. "Saturday Driving Restrictions Fail to Improve Air Quality in Mexico City." *Scientific Reports* 7 (1): 1–9.

<https://doi.org/10.1038/srep41652>.

³⁴ CPI. 2016. "Mexico City's ProAire Program." Centre for Public Impact (CPI). February 26, 2016. <https://www.centreforpublicimpact.org/case-study/mexico-citys-proaire-program/>.

³⁵ Gerardo Mejía, Francisco Obregon, and Robert Slott. 2003. "Workshop on Mexico Emissions Inventory." In *Newsletter*. Mexico DF.

http://www.mce2.org/newsletter/nwsltr_3/english/emissions_inventory.html.

environmental efforts of the metropolis and create the continuity that is needed for local projects and advances.

Discussion and Conclusion: Lessons from COVID-19

Air pollution in the world has been present for a long time and despite the efforts of many cities and nations, it continues to be a problem affecting the livelihood of millions of people. There have been many efforts to reduce air pollution in the world, including traffic reduction, as well as use of cleaner and more efficient fuels. Many started to accept air pollution as part of our daily lives, and instead began to find ways to live with it or place long term goals very into the future.³⁶

It was only until the COVID-19 pandemic surged, when people were forced to stay at home, were air pollution levels decreased in major cities to the lowest it has been in decades³⁷. According to a CNN report, major cities that suffer from the world's worst air pollution have seen reductions of deadly particulate matter by up to 60% from the previous year, during a three-week lockdowns period, including Beijing. This halt of industry and traffic proves that reducing air pollution is possible, but more strict policies are required for this to happen, where a more holistic approach is used instead of one that focuses of economic factors.

In conclusion, the Mexico City and Beijing metropolises are some of the areas with the oldest history of air pollution issues and regulations. Despite this, both of them still struggle to effectively and significantly reduce air pollution. More research should be done by statistically analyzing the effects that these

³⁶ US EPA, OAR. 2015. "Air Pollution: Current and Future Challenges." Overviews and Factsheets. US EPA. May 27, 2015.

<https://www.epa.gov/clean-air-act-overview/air-pollution-current-and-future-challenges>.

³⁷ CNN, Helen Regan. 2020. "Air Pollution Falls by Unprecedented Levels in Major Global Cities during Coronavirus Lockdowns." CNN. April 23, 2020.

<https://www.cnn.com/2020/04/22/world/air-pollution-reduction-cities-coronavirus-intl-hnk/index.html>.

regulations have had on the reduction of air pollution in order to compare both areas. In addition, considering the public opinion on these policies would create a more holistic approach to the research.

Bibliography

“Beijing Facts: Introduction, Location, History, Districts, Attractions.” 2019. Travel China Guide. September 30, 2019. <https://www.travelchinaguide.com/cityguides/beijing/>.

California Air Resources Board. NA. “History of California Air Resources Board.” NA. <https://ww2.arb.ca.gov/about/history>.

Carlos Rincón Mautner. 2019. “Mexico City.” Encyclopedia Britannica. January 9, 2019. <https://www.britannica.com/place/Mexico-City>.

CNN, Helen Regan. 2020. “Air Pollution Falls by Unprecedented Levels in Major Global Cities during Coronavirus Lockdowns.”

CNN. April 23, 2020.

<https://www.cnn.com/2020/04/22/world/air-pollution-reduction-cities-coronavirus-intl-hnk/index.html>.

CPI. 2016. “Mexico City’s ProAire Program.” Centre for Public Impact (CPI). February 26, 2016.

<https://www.centreforpublicimpact.org/case-study/mexico-citys-proaire-program/>.

China. Constitution of the People's Republic of China, Adopted on September 20, 1954 by the First National People's Congress of the People's Republic of China at Its First Session. [Rev. Translation]. Peking: Foreign Languages Press, 1961.

Davis, Lucas W. 2017. “Saturday Driving Restrictions Fail to Improve Air Quality in Mexico City.” *Scientific Reports* 7 (1): 1–9. <https://doi.org/10.1038/srep41652>.

Gobierno de Mexico. 2018. “Hoy No Circula.” Hoy No Circula. 2018. <https://www.hoy-no-circula.com.mx/>.

Hibler, M. 2004. “Taking Control of Air Pollution in Mexico City.” *IDRC - International Development Research Centre*, June. <http://hdl.handle.net/10625/29264>.

History.com Editors. 2009. “Water and Air Pollution.” Informative. HISTORY. November 6, 2009. <https://www.history.com/topics/natural-disasters-and-environment/water-and-air-pollution>.

Maricela Yip, and Pierre Madl. 2000. “Air Pollution in Mexico City.” December 14, 2000. <https://biophysics.sbg.ac.at/mexico/air.htm>.

Marlier, Miriam E., Amir S. Jina, Patrick L. Kinney, and Ruth S. DeFries. 2016. “Extreme Air Pollution in Global Megacities.” *Current Climate Change Reports* 2 (1): 15. <https://doi.org/10.1007/s40641-016-0032-z>.

Meredith McCormack. 2020. “Air Pollution.” Government. National Institute of Environmental Health Sciences. February 11, 2020. <https://www.niehs.nih.gov/health/topics/agents/air-pollution/index.cfm>.

Molina, L., Benjamin de Foy, O. Vazquez-Martinez, and Víctor-Hugo Páramo. 2009. “Air Quality, Weather and Climate in Mexico City” 58 (January): 48–53.

Pasick, Adam. 2014. “Beijing Broke Its Own Air-Quality Rules and Held a Marathon in Toxic Conditions.” *Quartz*. October 20,

2014. <https://qz.com/283665/beijing-broke-its-own-air-quality-rules-and-held-a-marathon-in-toxic-conditions/>.

Salcido, Alejandro, Susana Carreón-Sierra, and Ana-Teresa Celada-Murillo. 2019. "Air Pollution Flow Patterns in the Mexico City Region." *Climate* 7 (11). <https://doi.org/10.3390/cli7110128>.

Secretaria del Medio Ambiente de la Ciudad de Mexico. 2018. "Inventario de Emisiones de La Ciudad de Mexico 2016." September 2018. <http://www.aire.cdmx.gob.mx/descargas/publicaciones/flippingbook/inventario-emisiones-2016/mobile/#p=3>.

Silva Rodríguez de San Miguel Jorge Alejandro. 2019. "Management of Air Pollution in Mexico." *Management of Environmental Quality: An International Journal* 30 (3): 578–92. <https://doi.org/10.1108/MEQ-05-2018-0099>.

South Coast Air Quality Management District. NA. "History of Air Pollution Control." NA. <https://www.aqmd.gov/home/research/publications/history-of-air-pollution-control>.

UN Special Rapporteur. 2017. *Report of the Special Rapporteur on the Issue of Human Rights Obligations Relating to the Enjoyment of a Safe, Clean, Healthy and Sustainable Environment, 2016. Human Rights and the United States: Chapters 15-23 and Appendixes*. <http://blume.stmarytx.edu:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=edsgvr&AN=edsgcl.7171000300&site=eds-live&scope=site>. <https://www.epa.gov/environmentaljustice/los-angeles-area-environmental-enforcement-collaborative>.

Wang, Li, Fengying Zhang, Eva Pilot, Jie Yu, Chengjing Nie, Jennifer Holdaway, Linsheng Yang, et al. 2018. "Taking Action

on Air Pollution Control in the Beijing-Tianjin-Hebei (BTH) Region: Progress, Challenges and Opportunities.” *International Journal of Environmental Research and Public Health* 15 (2). <https://doi.org/10.3390/ijerph15020306>.

The Cinematic Portrayal of the Successful Psychopath

Sarah Diaz

Mentor: Patricia Owen, Ph.D.

St. Mary's University, San Antonio, TX

A common theme in popular cinema is the depiction of psychopathic characters, particularly those with antisocial personality disorder (ASPD) traits. ASPD characters are portrayed as sadistic, erratic, and violent with an impulse to engage in criminal activity (Leistedt & Linkowski, 2013). These characters are often unsuccessful in avoiding negative consequences for their criminal actions. Despite the attention given to ASPD, little is known about the portrayal of the successful psychopath within cinema. The successful psychopath is characterized by attainment of personal or professional success and the lack of historical or current criminal activity (Hall & Benning, 2006). Within the general population, successful psychopaths have been shown to display traits that negatively affect interpersonal relationships, which include a charming façade designed to manipulate, a lack of remorse, and pathological lying (Babiak, 1995; DeMatteo, Heilbrun, & Marczyk, 2006; Hall & Benning, 2006). The purpose of this study is to assess the portrayal of the successful psychopath in cinema. Movie characters who met criteria for high professional achievement and non-involvement with criminal activity and who were labeled as psychopaths in cinema plot summaries were rated as to the extent to which they met criteria of charm, manipulation, lack of remorse, and lying. Results from an analysis of 15 movies showed that successful psychopaths displayed high levels of charm, manipulative behavior, and lack of remorse. Results imply that the presence of the successful psychopath is overlooked by movie viewers even though this subtype may be just as destructive in the general population as is the unsuccessful psychopath.

The media is often cited as an important source of information about psychopathology which contributes to the way the general public perceives mental disorders. Popular cinema in particular has been shown to portray diverse mental disorders, and psychopathic characters, particularly those with antisocial personality disorder (ASPD) traits, are a common staple in movie narratives. ASPD characters are frequently depicted as violent, murderous, sadistic, unpredictable, and emotionally unstable. They are also known to display characteristics such as impulsiveness, poor behavioral controls, criminal activity, proneness to boredom, and lack of realistic, long-term goals (Leistedt & Linkowski, 2013). ASPD characters are termed unsuccessful as they accrue negative consequences for their actions such as criminal convictions, chastisement, harmful repercussions, and even death (Gao, Raine, & Phil, 2010). Despite the attention given to ASPD characters, little is known about the portrayal of the successful psychopath within cinema. The successful psychopath is characterized by attainment of personal or professional success often at the expense of others (Hall & Benning, 2006). In the general population, successful psychopaths are also characterized by having the core features of psychopathy (e.g. superficial charm and lack of remorse) and have been shown to display traits that negatively affect interpersonal relationships, which include a charming façade designed to manipulate, a lack of remorse, and pathological lying (Babiak, 1995; DeMatteo, Heilbrun, & Marczyk, 2006; Hall & Benning, 2006). It is interesting that theorists (Cleckley, 1941; Gao et al., 2010; Mullins-Sweatta et al., 2010) note that many individuals with psychopathic traits (e.g., CEO's, professors, lawyers, and politicians) are able to successfully obtain profitable careers within corporations and institutions by way of manipulation, pathological lying, and charm. It is estimated that the prevalence of successful psychopathy within the corporate world is about 3.5% (Gao et al., 2010).

Although there is abundant research on traits associated with the unsuccessful psychopath/ASPD both in the general population and in cinematic portrayals, research is limited on traits associated with the successful psychopath in general population studies. Additionally, to the best of this author's knowledge,

there are no published studies investigating the depiction of the successful psychopath in cinema. The purpose of this study is to provide an analysis of the portrayal of the successful psychopath in cinema.

Method

Sample

Full length commercial movies released in the United States between the years of 1987 and 2019 were viewed in their entirety. Movies were selected on the basis of featuring at least one main character who met criteria for successful psychopathy. Sources for locating movies included Internet streaming services such as Hulu and Amazon Prime Video. Key word search included movies with psychopaths/sociopaths, movies with manipulative characters, movies with successful businessmen/women, and movie plot summaries that indicated the presence of a successful individual who displayed psychopathic traits yet did not engage in criminal activity. Movie plot summaries that referenced murderous characters, serial killers, or criminals were eliminated from consideration. A total of 25 movies were viewed and of these, 15 (see Appendix) were selected as at least one main character was judged to meet criteria of the successful psychopath.

Procedure

To be categorized as successful psychopaths, characters showed achievement of personal or professional success and were successful in avoiding serious consequences (e.g., criminal conviction or death) as a result of their behavior. Characters' behavior was judged as to charm, manipulation of others, lying and deceit, and lack of remorse about actions that hurt others. In accord with the research of Hare (1991), charm was defined as having good social skills and being glib, talkative, and sometimes being flirty/sexual towards another person (or group of people) in order to persuade a person to think or act in a certain way that benefits the charmer. Manipulative behavior was defined as any action that involves coercing someone to think or act in a certain way (a behavior the receiving person may not want to perform) by bestowing the feelings of fear, guilt, or obligation on the receiver.

Manipulative behavior could involve control over a situation, or group of people, rather than a single person (Noggle, 2020). Lying and deceit was characterized as making a false statement (or statements) with deliberate intent to deceive a person or group of people.

A 6-point Likert rating scale ranging from 1 (no display of the trait) to 6 (extremely strong display of the trait) was used to determine the extent of each criteria. Ratings of 3 or below were labeled as a low characterization of a trait while ratings of 4 or above were labeled high. The outcome (or consequence) of each character's actions was rated as being either negative, positive, or having no consequence. A negative consequence was defined as an outcome that was unpleasant, harmful, or dissatisfying for the character. A positive consequence was defined as an outcome that was satisfying, desired, enjoyed, or intended by the character. Finally, no consequence was defined by the absence of either a positive or negative outcome.

Results

A total of 15 movies featuring 15 characters meeting the criteria for the successful psychopath were viewed. All characters were portrayed as achieving personal or professional success. Six of the characters were classified successful businesspersons such as stockbrokers, investment advisors, high-level management, and journalists. No characters were portrayed with a criminal history. Within the movie's narrative, over one-half of the characters experienced positive consequences ($n = 8$, 53%) while more than one-fourth of the characters faced negative consequences ($n = 4$, 27%). As an example of a positive consequence, Amy (the successful psychopath protagonist in *Gone Girl*) orchestrated her disappearance to attain revenge on her husband and successfully manipulated her estranged husband into staying with her. An example of a negative consequence was exemplified in *Cruel Intentions*, where the Kathryn's manipulative behavior leads the death of her step-brother and to her humiliating chastisement by her school peers.

A majority of the characters were judged as rating high on charm ($n = 14$, 93%) and high on showing no remorse for their actions ($n = 14$, 93%). For example, in *Shattered Glass*, the

character Stephen charms individuals by giving compliments and small gifts. Stephen also shows no remorse for creating and publishing multiple false articles in a highly reputable newspaper while repeatedly denying his actions. All of the characters were judged as rating high on manipulative behavior ($n = 15$, 100%) and lying ($n = 15$, 100%). An example of manipulative behavior occurs in *The Shape of Things* as the psychopathic protagonist Evelyn desires to re-create a young man for her art project. She uses sly suggestions, flirtation, and promises of sexual favors to convince the character Adam to substantially change his appearance. In Table 1 the average score for each categorical trait is shown.

Discussion

The results of this study of the cinematic portrayal of the successful psychopath finds that this subtype of psychopath is characterized by core features of charm, manipulative behavior, and lack of remorse for actions that negatively impact others. These features are in stark contrast to those of the ASPD/ unsuccessful psychopath whose impulsivity, risk-taking, and sensation-seeking lead to criminal sanctions. It is interesting that ASPD protagonists are well portrayed in cinema and that public perception of these unsuccessful psychopaths is somewhat accurate (Hesse, 2009; Leistedt & Linkowski, 2013). The successful psychopath, on the other hand, is far less represented in movies with the general public unaware of this subtype of psychopathy. (Gao et al., 2010). This underrepresentation has implications as it is well-established that movies serve not only to entertain but to educate. Owen (2012), for example, found that cinematic portrayals of schizophrenia were frequently negative, stereotypical, and inaccurate and that such misinformation can contribute to the pejorative views that society holds about schizophrenia. The same point may be true for the cinematic portrayal of psychopathy. Noncriminal or successful psychopaths can be just as destructive, and maybe even more destructive, as the stereotypical or unsuccessful psychopath (Fritzon, Brooks, & Croom, 2020) and the analysis of those traits characteristic of the cinema successfully psychopath can help to educate the lay public.

One limitation of this study concerns the small number of movies selected as depicting the successful psychopath. This study consisted of 15 movies that featured a successful psychopath as a main character, and due to time constraints, not all movies that could have met criteria for successful psychopathy were sampled potentially limiting generalizability. Another limitation relates to the lack of interrater reliability. With one coder responsible for selecting movies and rating characters, the ratings and movie selections may not fully correspond to correct representations of the variables measured. Future research can include a wider database of movies and include additional coders to assess interrater reliability.

Additional questions about the portrayal of the successful psychopath within cinema remain. Further research may be able to clarify if successful psychopaths display higher levels of interpersonal personality traits of psychopathy (e.g., charm, manipulation) than the more behaviorally-based antisocial traits (e.g., risk taking, impulsivity). Research as such may be able to contribute to a greater understanding of the differences (or similarities) among cinematic portrayals of criminal and non-criminal psychopaths.

References

- Babiak, P. (1995). When psychopaths go to work: A case study of an industrial psychopath. *Applied Psychology*, 44, 171-188. doi:10.1111/j.1464-0597.1995.tb01073.x
- Cleckley, H. C. (1941). *The mask of sanity* (1st ed.). St. Louis, MO: Mosby.
- DeMatteo, D., Heilbrun, K., & Marczyk, G. (2006). An empirical investigation of psychopathy in a noninstitutionalized and noncriminal sample. *Behavioral Sciences and the Law*, 24(2), 133-146. doi:10.1002/bsl.667

- Fritzon, K., Brooks, N., & Croom, S. (2020). *Corporate psychopathy: Investigating destructive personalities in the workplace*. Cham, Switzerland: Springer Nature Switzerland AG. Retrieved from <https://doi.org/10.1007/978-3-030-27188-6>
- Gao, Y., & Raine, A. (2010). Successful and unsuccessful psychopaths: A neurobiological model. *Behavioral Sciences and the Law*, 28(2), 194-210. doi:10.1002/bsl.924
- Hall, J. R., & Benning, S. D. (2006). The “successful” psychopath: Adaptive and subclinical manifestations of psychopathy in the general population. In C. J. Patrick (Ed.), *A Handbook of Psychopathy* (pp. 459–478). New York: Guilford.
- Hare, R. D. (1991). *The Hare psychopathy checklist—revised (PCL-R)*. Toronto: Multi-Health Systems.
- Hesse, M. (2009). Portrayal of psychopathy in the movies. *International Review of Psychiatry*, 21(3), 207–212. doi:10.1080/09540260902747441
- Leistedt, S. J., & Linkowski, P. (2014). Psychopathy and the cinema: Fact or fiction? *Journal of Forensic Sciences*, 59, 167-174. doi:10.1111/1556-4029.12359
- Mahmut, M. K., Homewood, J., & Stevenson, R. J. (2008). The characteristics of non-criminals with high psychopathy traits: Are they similar to criminal psychopaths? *Journal of Research in Personality*, 42(3), 679–692. <https://doi.org/10.1016/j.jrp.2007.09.002>
- Mullins-Sweatt, S. N., Glover, N. G., Derefinko, K. J., Miller, J. D., & Widiger, T. A. (2010). The search for the successful psychopath. *Journal of Research in Personality*. 44. 554-558. doi:10.1016/j.jrp.2010.05.010.
- Noggle, R. (2020). The ethics of manipulation. Retrieved from <https://plato.stanford.edu/entries/ethics-manipulation/>
- Owen, P. R. (2012). Portrayals of schizophrenia by entertainment media: A content analysis of contemporary movies. *Psychiatric Services*, 63(7), 655-659. doi:10.1176/appi.ps.201100371

Social interactions between peers lead to more typical behavioral development in a motherless beluga (*Delphinapterus leucas*) calf

Wendy Ornelas

Mentor: Heather M. Hill, Ph.D.

St. Mary's University, San Antonio, TX

A Cook Inlet beluga calf was stranded in September 2017 near Alaska at an estimated age of one month. The calf was rehabilitated in human care 24 hours a day for six months until he was deemed non-releasable and transferred into the care of SeaWorld San Antonio. The purpose of the current study was to compare the social interactions of this hand-reared, motherless calf to those of two other similar aged calves reared by their mothers. Instantaneous sample points across a 6-min session were collected hourly 5-7 days per week for the focal calf and his companions from April 2018 until April 2019. The results suggested that despite not having a mother, TYO was developing well even without a mother. Inclusively, TYO solo floating and swimming were higher than his two reference peers, his swim with others and motor play were more similar than different. These results suggest that the lack of maternal care may not produce only negative effects on the development of a calf, especially if similar-aged conspecifics are present. This study illustrates the importance of comparative research in which knowledge from one species can be applied to species of similar characteristics (e.g., mammals with long periods of development and parental care).

*Key Words: behavioral development, calf behavior, maternal care, beluga, *Delphinapterus leucas**

Beluga calves do not only learn how to regulate their swim and respiratory pattern by observing their mothers, but they also learn how to interact with other belugas socially. Yet, what

if a calf does not have a mother or a surrogate to learn from and is instead reared by humans? How will the lack of a mother affect the calf's development over time?

Beluga calves (*Delphinapterus leucas*) depend on their mothers for the first two years of their life (Hill, 2009; Hill et al., 2013, 2018; Krasnova et al., 2006, 2012, 2014). In one captive population, mothers and calves spent 48% of their time together over a two-year period with calves initiating 45% of their shared social interactions (Hill et al., 2018). Physical contact between mother and calf is important to the development and maintenance of mother-calf bonds and calf-calf bonds during the first two years of life (Hill et al., 2018; Hill & Campbell, 2014). Contact by mothers may also serve as a way to incorporate discipline and meet the calf's survival needs. These early interactions are important because they encompass bond formation between mothers and their calves as well as develop calf social interaction skills (Hill, 2009; Hill et al., 2013, 2018; Krasnova et al., 2006, 2012, 2014).

The frequency with which the mother and calf interact suggests that this early period is critical to calf development. The first half of the first year is important for physical development and safety. Calves rejected or abandoned by their mothers do not survive unless human intervention occurs (Hill & Campbell, 2014). When bonds are formed between mother and calves, the second half of the first year is characterized by early independence and social interactions with calves of similar age or other mother-calf pairs. Early independence is defined by calves increasing their distance away from their mothers, displaying more frequent independent swims, and socializing or playing with others (Hill, 2009; Hill et al., 2013; Hill et al., 2007; Hill et al., 2018). Despite increased independence, maternal care remains essential for the calf's developmental progress. The presence of the mother provides opportunities for the calf to imitate and learn about species-typical behaviors (Krasnova et al., 2012, 2014). Similar to human mothers, beluga mothers act as models to

learning about social cues within the environment before weaning.

Different types of parenting styles exist within beluga mothers and calves much like in humans. Some mothers are overprotective and allow little to no separation while others are permissive allowing more exploration (Hill, 2009; Hill et al., 2007; Hill et al., 2013; Krasnova et al., 2014). Attachments between mothers and calves are important to consider because they allow calves to leave the protection of the mother and explore new experiences. Mothers that tend to explore objects and interact more with other belugas may have calves that are likely to do the same. Developmentally with time, all calves displaying species appropriate behaviors should increase the number of interactions with other pod members and locomotive play (Krasnova et al., 2012, 2014). Many interactions between calves include tagging each other, which integrates locomotive play and social play. Existing research has not been able to explore the interaction between maternal style and offspring variability. It is clear that many variables influence calf development, and these still need to be explored.

One of these variables might be allocare as previous research demonstrates that the survival of calves is dependent not just upon the maternal care received but also on the network of available social support (Hill & Campbell, 2014). Allocare may also provide safe opportunities for calves to develop independence from their mothers as the calves are received by and cared for by another beluga (Krasnova et al., 2006, 2014). Allocare produces different patterns of behavior when the mother is still available. Some behaviors with allomaternal partners include maintaining contact or proximity, carrying, nursing, or protecting the young conspecific physically from threats (Hill & Campbell, 2014; Krasnova et al., 2006; Leung et al., 2010). Also, when comparing mother-calf swims, allocare interactions were significantly shorter in duration (Hill & Campbell, 2014). These patterns suggest that allocare events do not replace the bond formed between calves and their mothers (Hill & Campbell.,

2014). It is important to note that allocare events deviate from typical social interactions as allocare providers must alter their behaviors to care for the young animal in the absence of the primary caregiver. However, past research demonstrates that simple proximity is not enough to induce allocare efforts by any beluga, especially if a calf does not reciprocate any social interactions initiated by other belugas (Hill & Campbell., 2014). If a calf does not respond to maternal care efforts, it seems likely that the development will be negatively affected. Limited research currently exists regarding the outcome of orphaned or rejected beluga calves that are raised by humans.

In the current study, the investigator observed the social behavior of three captive beluga calves at SeaWorld San Antonio (SWSA). The focus of this study was TYO, a rehabilitated beluga that had been nurtured by humans since he was rescued at approximately one month of age. He was transferred to SWSA at around 7 months where he ultimately lived and interacted with a variety of belugas, including two similar aged calves (KEN and INK) raised by their mothers. These calves provided reference points for developmental milestones with which to evaluate TYO's behavior. The purpose of the current study was to explore the possible effects of not having a maternal figure during the critical stages of development. This led the investigator to hypothesize how the development of a calf could be improved by maternal care or by the presence of similar aged peers. Five behaviors (solo swim, solo float, swim with other, object play, motor play) were selected to assess calf development.

Method

Subjects

Three beluga calves (*Delphinapterus leucas*) were observed for 12 months for the current study. The focal animal, TYO, was born approximately in September 2017, in the Cook Inlet Bay and was found stranded at about a month old. He was cared for and rehabilitated by humans 24 hours a day until his transfer to SeaWorld San Antonio (SWSA) after the US

government deemed him non-releasable. When TYO arrived at SWSA, he did not respond to the allomaternal care of an adult female and preferred the nurturing of humans. When TYO was integrated with the rest of the beluga population, the training and veterinary staff discovered that he was more likely to swim with a Pacific white-sided adult female dolphin, BET (*Lagenorhynchus obliquidens*), who had raised several offspring. It is possible that her smaller size may have been more comfortable and similar to humans.

TYO was age-matched with another calf, INK. INK was also 7 months and bonded with his mother, CRI. CRI was approximately 32 years old and has raised three other offspring. A third calf, KEN, was about a year older. KEN was 21 months and bonded with his mother, LUN. LUN was 17 years old and had given birth to two other calves, rearing only one calf. INK and KEN will be used as reference points to which to compare TYO's behavioral development.

Social groupings were determined by training staff. TYO was integrated with other belugas gradually based on the qualities of companions. KEN and LUN were grouped with TYO more frequently than INK and CRI, but neither mother-calf pair was with TYO all the time (Table 1). TYO was always housed with a companion, usually BET.

Sample

The present study used data from archived ethograms that were collected by trainers daily from April 2018-April 2019 on TYO and his companion animals. The behaviors of TYO and his companions were recorded almost every hour using an instantaneous sampling method for six minutes. Periodically, data were not collected for TYO and his social grouping (Table 1).

Measures

TYO social behavior is the main dependent variable for the present study. Five specific behaviors were evaluated: solo swim, solo float, swim with other, object play, and motor play.

The data were collected with instantaneous sampling and had to be converted to the average proportion of observation time. To do this conversion, the investigator first summed each category of interest (i.e., if two of the six sample points were marked then a sum of two was calculated) and then divided summed values by six as there were six intervals for each observation (e.g., using the example of two- $2/6 = .33$).

Procedure

Ethogram Data Collection

A paper ethogram that listed about 30 different behavioral categories was used to collect data on TYO and each companion animal every minute for six minutes each hour of a day. As the focal animal, the behaviors of TYO were recorded first followed by the behaviors of each companion animal. Behavioral states such as solo swimming, solo floating, swim with others were mutually exclusive, which means only one behavior could be recorded for each one-minute interval. Two other behaviors, motor play and object play, were sometimes recorded as behavioral states and sometimes recorded as ongoing behavioral events.

The data from the paper ethograms were entered into Excel to begin data processing. Once the data had been converted to numbers, data compression into proportions was performed per session as described above. Following the session data compression, all averaged sessions in a day were averaged together. These daily averages were compressed one more time into a monthly average. As seen in Table 1, the available data varied per calf over time.

Table 1
Summary of Monthly Data per Calf

Month	Days of available data	TYO	KEN	INK
2018				
April	30	27	18	0
May	31	31	31	0
June	30	30	30	0
July	31	31	31	0
August	31	31	31	0
September	30	30	11	0
October	22	22	10	0
November	13	13	1	6
December	0	0	0	0
2019				
January	17	3	1	1
February	28	4	2	1
March	31	31	28	7

Statistical Analysis

To test if there were overall differences between calves for five behaviors (solo swim, solo float, swim with other, object play, and motor play), a multivariate 1-way ANOVA was conducted.

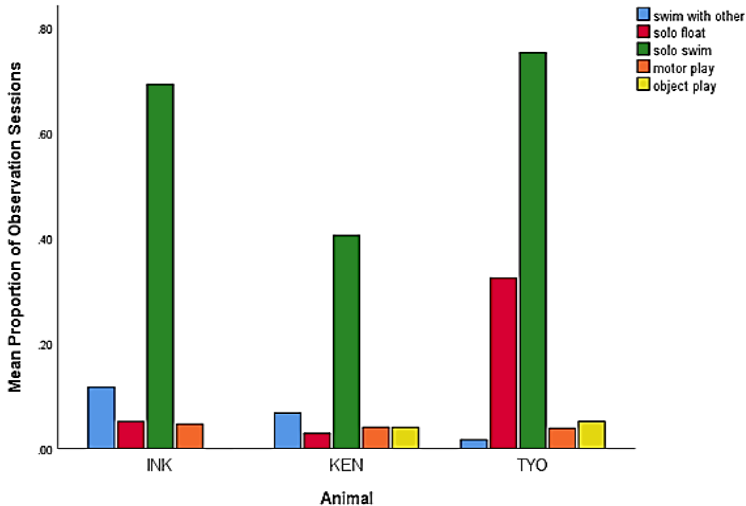
Hotelling’s Trace was reported following a violation of the sphericity assumption. Follow-up univariate 1-way ANOVAs with Dunnett T3 post hocs were conducted due to heterogenous variances.

Results

A multivariate analysis one-way ANOVA was conducted to evaluate the effect of individual animal on all five of the dependent variables. As expected, the results of the multivariate analysis indicated a significant effect, $F(10, 898) = 33.45, p < .001, \eta^2 = .27$. A series of one-way ANOVAs was conducted to determine which dependent variable the animal is influencing. The results indicated that all behaviors but motor play were significant: swim with other, $F(2,454) = 21.55, p < .001, \eta^2 = 0.09$; solo float, $F(2,454) = 68.69, p < .001, \eta^2 = .23$; solo swim, $F(2, 454) = 71.23, p < .001, \eta^2 = .24$; object play, $F(2,454) = 3.96, p < .001, \eta^2 = 0.02$. Figure 1 summarizes these findings.

Figure 1

Mean Proportion of Specific Behaviors per Calf



Dunnett T3 post hoc tests were conducted to assess individual differences on four of the five behaviors because motor play was the same for all three calves (Table 2, Figure 1). The results for swim with other indicated that TYO engaged significantly less than KEN ($p < .001$), while TYO was the same as INK. The second behavior was solo float and TYO displayed significantly more than KEN and INK ($p < .001$, respectively). No difference was found between KEN and INK. For solo swim TYO and INK were the same but TYO exhibited significantly more than KEN ($p < .001$). For object play, TYO and KEN were the same, but TYO engaged in significantly more than INK ($p < .001$).

Table 2
Descriptive Statistics per Behavior per Calf

	Animal	Mean	Std. Deviation	N
Swim with other	INK	.1164	.25236	18
	KEN	.0678	.11717	189
	TYO	.0418	.03965	250
Solo float	INK	.0516	.07344	18
	KEN	.0292	.05242	189
	TYO	.3241	.35584	250
Solo swim	INK	.6919	.38194	18
	KEN	.4049	.31720	189
	TYO	.7523	.28654	250
Motor play	INK	.0465	.09912	18
	KEN	.0407	.10163	189
	TYO	.0385	.04881	250
Object play	INK	0.000	0.00000	18
	KEN	0.0402	0.06597	189
	TYO	.0517	0.09336	250

Discussion

The purpose of the present study was to explore the possible effects of not having a maternal figure during the critical stages of development and if peers could positively influence beluga (*Delphinapterus leucas*) calf behaviors. For the current study, three beluga calves were observed for 12 months. TYO was the main focus of the current study with the two other calves acting as references for his development. TYO was a stranded, rehabilitated, non-releasable beluga calf from the endangered Cook Inlet beluga population in Alaska, USA. He was hand-reared 24 hours a day by humans as they stabilized his health. TYO was transferred into the care of Sea World San Antonio (SWSA) at approximately 7 months old. It is possible that being raised by humans and not by a beluga mother may have caused detrimental effects to his development. TYO was paired with an adult female beluga to act as a surrogate, but he did not bond with her. This lack of bonding was not unexpected as past research has demonstrated that simple proximity is not enough to induce allocare efforts by a surrogate mother (Hill & Campbell, 2014). When TYO was integrated with the beluga population, the trainers found that TYO was more likely to interact with an older female Pacific white-sided dolphin (BET) as well as his aged matched peers. In fact, TYO preferred to swim with BET when he swam with others. Anecdotally, TYO swam side-by-side with BET instead of in a mother-calf position where calves can be found under their mothers, near their mammary slits (i.e., infant position). Allocare does not replace the bond formed between calves and mothers, but instead can facilitate calf development in terms of social interactions, swim development, and other motor and play behaviors.

Based on the lack of a typical mother-calf bond, TYO was expected to have atypical development, especially in social interactions and solitary behavior. Five behaviors were examined for a year following his inclusion with belugas at SWSA. The results demonstrated that TYO did display more solo floating, independent swimming, and object play than his two male peers.

The differences in solitary behavior were expected as he did not have the same mother-calf bond as his peers, KEN and INK. However, TYO swim with others and motor play were significantly similar than different from KEN and INK. These social and independent developmental milestones suggest that TYO was developing similarly to his peers and was engaged in activities expected for his age. For example, object play occurred at similar rates between TYO and KEN as they had more opportunities to interact in the same pool when objects were present. INK was not present with TYO as often as KEN and thus did not have the same opportunities for object play when housed with TYO.

Based on these limited behaviors and comparison to two aged matched peers, it seems that maternal care was not essential to TYO development since he was within a supportive environment. In this secure environment, TYO interacted with similar aged peers (KEN and INK) who could have facilitated his behavioral advancements. The findings in the current study are important because they illustrate the importance of a secure environment for a calf without a mother. Calves rejected or abandoned by their mothers do not survive unless human intervention occurs (Hill & Campbell, 2014). TYO experience demonstrates the importance of human care for stranded animals, especially young animals.

Although the data were comprehensive for TYO (i.e., six minute of observation every hour almost every day for 12 months), there were limited data for the two reference animals, especially, INK. There were several months where no data were collected for INK, which caused difficulty in comparisons because his data were extremely variable. As seen in Table 2, the number of available observations for each calf varied greatly and this variability affected the patterns of behavior observed. For example, the swim with other data showed that TYO was significantly lower than INK, but Figure 1 shows TYO and INK engaging at the same amount. Additionally, the data for this study were collected using an instantaneous sampling method, which

limits the recording of all behaviors to a single instance. This technique leads to under reporting of rare events. Trainers at SWSA limited TYO's access to specific companions when caring for his physical ailments, which may have delayed his social development. Once TYO had more consistent access to similar-aged companions, his development approached expected milestones (Hill, 2009; Hill et al., 2013; Krasnova et al., 2006, 2014).

The longer TYO is integrated with more belugas, the greater his developmental progress. Although the presence of a mother would have provided opportunities for TYO to imitate and learn about species-typical behaviors (Krasnova et al., 2012, 2014), his development continues to approach typical milestones as he has the opportunity to interact and mimic the behaviors from his similar aged peers who were reared by their mothers. Future research should examine the developmental trends and social interactions of TYO and his peers using archived video footage. This study would enable the researcher to more accurately assess the amount of time, the role of initiator, and the types of social interactions, play behaviors, and general motor development for calves with and without their mothers. Comparative studies between species with similar characteristics (e.g., mammals with long periods of development and parental care) create opportunities for information to be shared and applied to similar situations. As in this study, understanding the importance of peers in human development when parental figures are not available informed the management practices utilized in the care of a stranded non-releasable beluga calf.

References

- Hill, H. M. (2009). The behavioral development development of two beluga calves during the first year of life. *International Journal of Comparative Psychology*, 22, 234-253.
- Hill, H., Campbell, C., Dalton, L., & Osborn, S. (2013). The first year of behavioral development and maternal care of beluga (*Delphinapterus leucas*) calves in human care. *Zoo Biology*, 32, 565-570. <https://doi.org/10.1002/zoo.21093>
- Hill, H., & Campbell, C. (2014). Allocare depends on social composition for belugas (*Delphinapterus leucas*) in human care. *International Journal of Comparative Psychology*, 27, 501-514.
- Hill, H., Dietrich, S., Jantea, R. F., Garza, S., & Lacy, K. (2018). The frequency of contact in beluga (*Delphinapterus leucas*) calf social interactions. *Aquatic Mammals*, 44(1), 62-75.
- Hill, H.M., Greer, T., Solangi, M., & Kuczaj II, S.A. (2007). Evidence for maternal styles in captive bottlenose dolphins. *International Journal of Comparative Psychology*, 20, 34- 53.
- Krasnova, V. V., Bel'kovich, V.M., & Chernetsky, A.D. (2006). Mother-infant spatial relations in wild beluga (*Delphinapterus leucas*) during postnatal development under natural conditions. *Biology Bulletin*, 33(1), 53-58. <https://doi.org/10.1134/S1062359006010079>
- Krasnova, V. V., Chernetsky, A. D., Kirillova, O. L., & Bel'kovich, V. M. (2012). The dynamics of the abundance, age, and sex structure of the Solovetsky reproductive gathering of the beluga whale *Delphinapterus leucas* (Onega Bay, White Sea). *Russian Journal of Marine Biology*, 38, 218-225.
- Krasnova, V. V., Chernetsky, A. D., Zheludkova, A. I., & Bel'kovich, V. M. (2014). Parental behavior of the beluga whale (*Delphinapterus leucas*) in natural environment.

Biology Bulletin, 41, 349-356.

<https://doi.org/10.1134/S1062359014040062>

Leung, E. S., Vergara, V., & Barrett-Lennard, L. G. (2010).

Allonursing in captive belugas (*Delphinapterus leucas*).

Zoo Biology, 29, 633-637.

<https://doi.org/10.1002/zoo.20295>

Observations of Helium Pickup Ions in the 2019 Focusing Cone Encounter

Zoe Vanover¹, R. Gomez¹, S.A. Fuselier²

Mentor: Roman Gomez, Ph.D.

¹St. Mary's University, San Antonio, TX

²Southwest Research Institute, San Antonio, TX

Interstellar pickup ions enter the solar system in a neutral charge state. Neutral atoms with trajectories near the Sun come under its gravitational influence and are focused downwind of the Sun to a distance, which depends on their mass. Interactions within the solar radiation environment ionize the interstellar neutrals, which are subsequently picked up by the interplanetary magnetic field (IMF). Since we're approaching a solar minimum, we would expect to see the radiation environment decrease, which would result in the increase of hydrogen protons in the cone due to the decrease in the production of Lyman alpha particles. While we do see an increase in hydrogen particles, we cannot determine what is coronal hydrogen or pickup hydrogen and it has yet to be understood how to distinguish between the two. The solar wind and the ion population have very similar compositions; however, we are able to differentiate the two by the wider spread of velocities of pickup ions with an upper limit of 2x the solar wind. The pitch angle, also known as the preferred orientation of the plane of the PUIs, can be calculated by taking the angle between the magnetic field and the direction of the flow of particles. The magnetic field is subject to fluctuations as well as the production of the particles themselves causes turbulence. Both these sources of turbulence cause pitch angle scattering which is being investigated for more accurate data acquisitions.

1. Introduction

The magnetic field of the Sun and its associated radiation environment is a complex system that extends to the termination shock, the point at which the solar environment gives way to interstellar space. Within this environment, the solar wind, a

constant stream of plasma particles, propagates with the Sun's interplanetary magnetic field (IMF). Outside the termination shock resides a mixture of neutral and ionized particles. The ionized particles meet the solar magnetic field at the termination shock and are projected outward in a different direction due to the Lorentz force interaction. However, if these particles are neutral, they can propagate past the magnetic fields.

While the solar system circumnavigates the galactic center at 230 km/sec, it moves at a much slower 26 km/sec with respect to the surrounding interstellar medium (ISM) (McComas et al., 2009). Neutral particles originating in ISM enter the solar system at the same speed and opposite direction. Since they are neutral, they are unaffected by the IMF. Particles with trajectories near the Sun come under its gravitational influence and are focused downwind of it. The resulting focusing regions of enhanced interstellar neutral density are called focusing cones and their focal distances downwind of the sun should depend on their mass. At this writing, only the helium focusing cone has been directly observed (Gloecker et al., 2004 and Noda et al., 2001). It is expected that cones of more massive species like oxygen and nitrogen should have shorter focal distances than helium, which is slightly larger than 1 AU. Like the helium cone, these cones are constant structures and the Earth encounters them annually from Mid-November to Mid-December.

Interstellar neutral particles can be ionized at any point during their travel within the solar system. Given a relatively constant interaction cross-section for proton-proton charge exchange, these focusing regions result in a higher particle ionization rate. The ions produced in these interactions are called pickup ions or PUIs. Following their production, they are "picked up" in the rest frame of the Solar Wind (SW) by the outwardly propagating IMF. Ions are easier to detect than neutral particles so measurements of the helium cone were made with ion-sensitive instruments. It bears mention that interstellar hydrogen, unlike more massive species, does not form a focusing cone. The radiation environment of the Sun, particularly Lyman- α

ultraviolet (UV) photons, effectively competes with its gravitational attraction leading to a hydrogen depletion region during the cone encounter period. Production of Lyman- α photons is known to decrease during the minima of the solar cycle. This results in a decreased radiation environment, which could lessen the hydrogen depletion observed during the cone encounter. Observing interstellar hydrogen is further complicated by the presence of the hydrogen geocorona, which is a population of hydrogen neutrals that is constantly associated with the Earth. Recent measurements by I. I. Baliukin et al., (2019) also shows that the geocorona extends out to the orbit of the Moon. Therefore, even when hydrogen, in the form of PUIs, is visible to instruments in near-Earth orbit, we cannot determine whether it is of interstellar or geocoronal origin.

PUIs have very specific characteristics that can be used to distinguish them from other particles. The atomic composition of the ISM does resemble that of the solar wind; however, the distances at which interstellar PUIs are formed limit them to single ionization states (He^+ , O^+ , etc.). In contrast, SW ions are produced very close to the Sun. The high temperatures in this region lead to the production of multiple ionized species (He^{2+} , O^{6+} , etc.). Another distinguishing characteristic of PUIs is their large spread in velocities. PUIs range from their heliospheric entry velocity of ~ 26 km/s to an upper limit of approximately twice the SW velocity (Vasyliunas & Siscoe, 1976; Moebius et al., 1985). This broad velocity range is caused by the gyratory motion of the particles while associated with the IMF. Under non-turbulent conditions, the gyratory plane of the PUIs is determined by relative orientations of the SW and IMF vectors. The angle the plane makes relative to the IMF vector is called the pitch angle. Over long timescales, the SW is relatively constant, but the IMF is subject to fluctuations that contribute to non-linear processes in the region. These rapid IMF changes, along with the contributions from PUI production, cause turbulence in the region which scatters the ions in pitch angle.

The MMS Mission is intended to study the process of magnetic reconnection, a means of energy transfer between the solar plasma environment and that of the Earth. The coupling of IMF lines with geomagnetic field lines facilitates the transfer of mass and energy between these environments. Magnetic reconnection is also involved in other observable phenomena, like sunspots and auroras. The energy stored in magnetic fields is released when these coupling events occur. The energy released from the magnetic field is imparted to the particles surrounding it, causing the acceleration. The accelerated ions are then observable by a plasma instrument, which scans differentially in energy and linearly in angle. The four Hot Plasma Composition Analyzers of the Magnetospheric Multiscale Mission (MMS-HPCA, Young et al., 2016) were intended to study the role of ion composition in the magnetic reconnection process.

As a happenstance, these instruments are also well-suited to observe other ion populations, specifically interstellar pickup ions (PUIs). Multiple forays into the near-pristine SW environment have allowed for multiple observations of this environment. The results of the most recent cone encounter period are the subject of this work.

HPCA is an electrostatic analyzer (ESA) based ion-optical instrument that observes charged energetic particles in the 1 eV/e - 40 keV/e range. It has a sizable geometric factor that allows a large instantaneous view of charged particle phase space (a 6-dimensional phase space with 3 velocity and 3 spatial dimensions). This allows HPCA to adequately cover the broad velocity distribution of the PUIs. As a secondary advantage, the broad energy range allows the influence of the SW to be filtered out, which removes a significant source of noise. To further assist with SW-filtering, the HPCAs are outfitted with a radio frequency attenuation protocol (Burch et al, 2005) that reduces proton flux at the detector by up to a factor of 1,000x. Finally, ion composition is determined by combining the ESA and the optically coupled time-of-flight (TOF) mass spectrometer section positioned at the ESA exit.

2. Observation and Analysis

For this study, we used MMS data acquired on 5 December 2019 from 03:00-04:00 UTC. Data was collected in burst mode, which is the highest temporal resolution available. HPCA scans the full sky (4π steradians) every 10 seconds. At the time of the observations, the spacecraft was outside of Earth's bow shock at a geocentric solar ecliptic (GSE) distance of $29.3 R_E$ on the dusk flank of the Earth at orbital apogee. The environmental conditions are seen in Figure 1. The panels show, from top to bottom, the magnetic field components, ion velocity components, HPCA measured energy-per-charge (E/q) dependent proton flux, and the FPI and HPCA measured ion densities. The magnetic field during this time period remained reasonably constant in the x-, y-, and z-components. The x-component of the magnetic field was constant and remained near zero, neither Sunward nor anti-Sunward. Any fluctuations seen in the plot for B_x are negligible as they were not present for a considerable amount of time. B_y had an averaged -2 to -3 nT and was directed consistently dawnward (westward). B_z , on the other hand, initially averaged 2 nT and slowly inverted from northward to southward over the interval.

In the second panel are pictured the ion velocity components measured by the Fast Plasma Investigation (FPI). FPI has a similar geometric factor to HPCA and nominally sweeps from 10 eV/e to 30 keV/e (Pollock et al., 2014). However, in the SW, the instrument scans a truncated energy range. This modified energy range allows higher resolution energy measurement, which leads to higher resolution measurements of the SW velocity components. As shown in the panel, the ion velocity components remain constant for the entirety of the interval. Further confirming that we are in the SW environment, the x-component shows strong anti-sunward velocities ~ 300 km/s.

A criterion used for establishing interval validity is to

inspect the proton flux pattern to ensure an absence of flux above 5 keV/e. Such is the case for this interval as shown in the third panel of Figure 1. The flux is strongly peaked around 600 eV/e, corresponding to the energy of the SW. This criterion, along with the magnetic field and velocity measurements, clearly establishes two things: the instrument is in the SW and is disconnected from the magnetic field environment of the Earth.

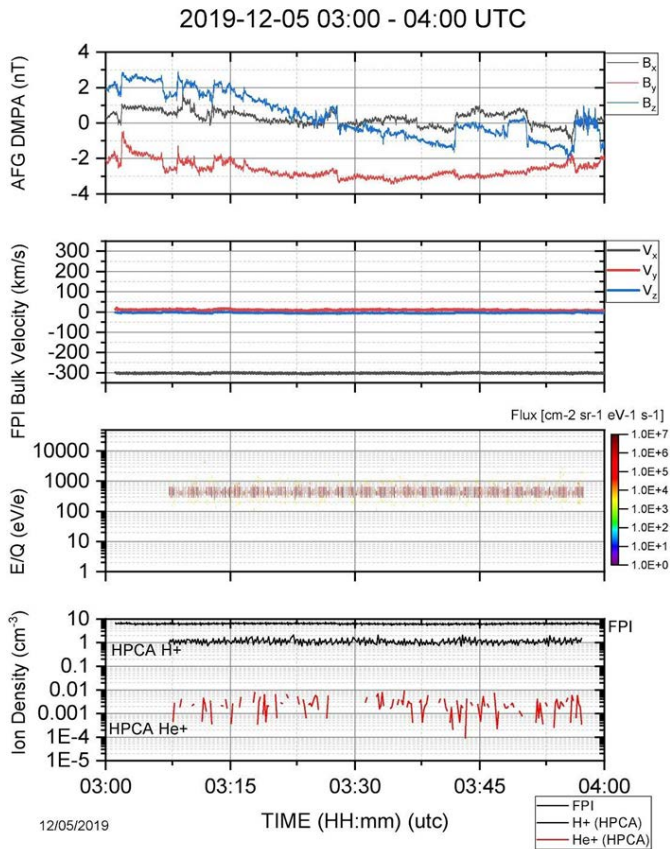


Figure 1: Environmental conditions for the SW encounter period on 5 December 2019 03:00-04:00 UTC. Pictured in the panels above (top to bottom) are the magnetic field components, ion velocity components, HPCA measured energy-per-charge (E/Q)

dependent proton flux, and the FPI and HPCA measured ion densities. In the top panel, the x-, and y-components of the magnetic field remain relatively constant over the interval. B_x is steady and is directed neither Sunward nor anti-Sunward for any appreciable period of time. B_y is constantly directed downward, while B_z is initially directed northward for the beginning half of the interval and slowly inverts southward. In the second panel, in contrast, the ion velocity components are constant throughout the interval with a strong anti-sunward x-component at about 300 km/s, confirming that the instrument is in the solar wind. The third panel displays the proton flux measured during this time period. HPCA measured the flux to be strongly peaked around 600 eV/e. The absence of proton flux ≥ 5 keV/e indicates no connection to Earth's magnetic field environment. The bottom panel contains the FPI measured ion density, and HPCA measured hydrogen and helium ion densities. FPI is operating in a mode that is optimized for solar wind measurement while HPCA operates in its standard mode. The differences between these operational modes led to different density measurements. The presence of singly charged helium indicates that we are located in the helium focusing cone.

As mentioned previously, during this interval of time, FPI operated in a mode that was optimized for solar wind measurement, while HPCA was operating in its standard mode. These discrepancies result in differences in ion density measurements. An example of these differences is shown in the bottom panel of Figure 1. HPCA's large geometric factor and large energy steps underestimate particle flux and report a decreased density when the plasma fills one or two energy steps. FPI, on the other hand, uses microstepping when observing the solar wind environment, which combats the inherent poor resolution. FPI measures much faster than HPCA so it is also less susceptible to detector saturation and dead-time effects. As shown in the bottom panel, the hydrogen ion density measured by FPI is significantly larger than that of HPCA and much closer to the expected value. Singly charged helium is also present, which confirms that the MMS spacecraft are within the helium focusing cone.

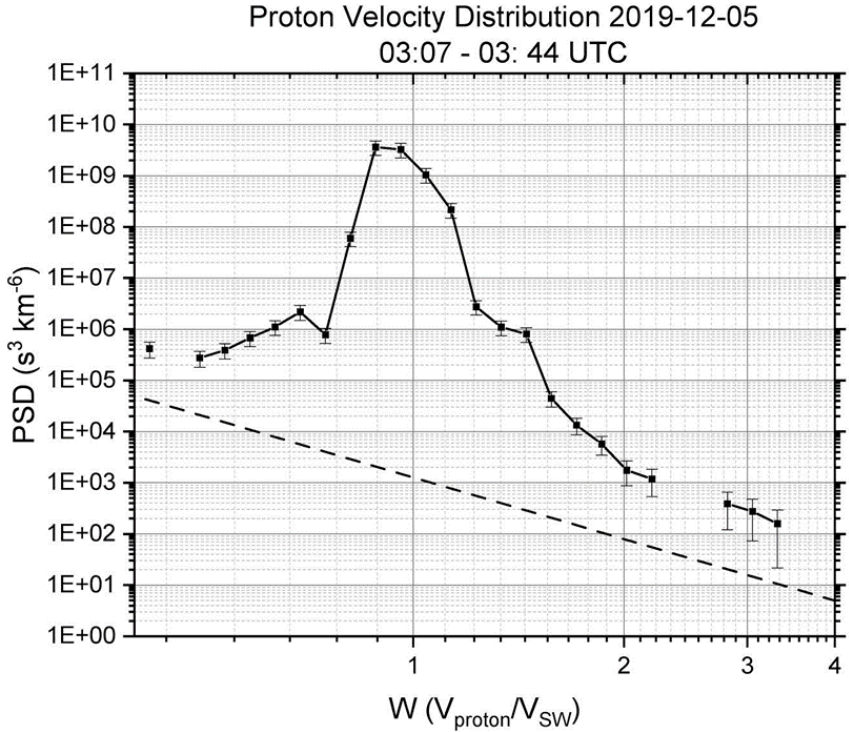


Figure 2: 1D hydrogen ion velocity distribution measured 5 December 2019 03:07-03:44 UTC. Pictured above we see the PSD measured by HPCA collapse into a 1D representation. On the vertical axis is the PSD in units of $s^3 km^{-6}$ logarithmically. The horizontal axis has the ion velocity normalized to the average solar wind velocity. The peak in PSD from approximately $W=0.7$ to $W=1.2$ is due to the solar wind flux, which peaks near $W=1$. Before and after this peak, the PSD contributions are due to PUIs produced from neutral hydrogen in the region from the Earth's hydrogen geocorona. (Fuselier et al., 2010; Baliukin et al., 2019) Further evidence that these are PUIs is that these contributions die off at $W=2$, which is twice the solar wind velocity in this frame (Vasyliunas & Siscoe, 1976; Moebius et al., 1983). The error bars include contributions from Poisson counting statistics, thermionic emission from detectors, and the relative uncertainties in energy and angular measurements. The dashed line in the figure represents the one-count background of the HPCA instrument and includes the effect of the instrument's double-coincidence measurement scheme.

A well-known characteristic of PUIs is their broad velocity distribution, which differs from the more narrow velocity distribution of the solar wind. Observing PUIs requires an instrument with a large geometric factor that is able to fully-resolve the broad range of velocities. In Figure 2, we're able to see this full range with the 1D hydrogen ion distribution plot. The vertical axis is the phase space density (PSD) on a logarithmic scale and the horizontal axis is the velocity normalized to the solar wind average velocity. The flux of protons from $W=0.7$ to $W=1.2$, centered around 1, is due to the solar wind. The flux outside of the solar wind can be attributed to PUIs originating from the region of the hydrogen focusing cone in Earth's geocoronal environment; it dies off at $W=2$, which is 2x the solar wind in this frame. This further confirms that we are detecting PUIs.

When measuring the phase space density (PSD) of the hydrogen protons, there are multiple sources of noise such as shock noise, thermionic emission, penetrating radiation, etc. HPCA has a double-coincidence scheme. It is necessary and sufficient to have 2 events define a singular measurement instance that occurs in a 256 ns window. When the charged particle interacts with the carbon foil, it creates two products: an emitted charged electron and a neutralized atom. This emitted charged electron is directed to one of the start anodes creating the start signal for the first event. Then, the stop signal is the neutralized atom being detected by the microchannel plate. The double coincidence scheme reduces the noise rate resulting in a better signal to noise discrimination. This then ensures that all the counts on the levels excluding ones with the solar wind contributions are real counts. The remaining noise factors are taken into account with the one count background line as all the flux above the line is real measurements and all beneath is background contamination. This along with the RF attenuation signal procures accurate data.

HPCA is an ion-optical instrument that measures the energy-to-charge (E/q) ratio of ions entering the toroidal ESA.

The time-averaged flux is seen in Figure 3. Ions enter the instrument's aperture and are then accelerated with a 15 kV potential upon exiting the ESA (Young et al., 2014). From there, the ions collide into the carbon foils, which emits an electron and neutralizes the ion. The time-of-flight (TOF) is determined from the start and stop signals produced from the electron and ion impacts. The TOF measurement combined with the E/q ratio allows the ion species to be identified.

The lower and upper TOF limit locations of each species are indicated by solid and dashed lines respectively. From left to right, mass-to-charge ratios of 1, 2, 4, 16, and 20 appear. On the 16 different energy levels and in 160 ns, the average flux of these species is indicated by the corresponding colors defined on the right. We can see that there is a high flux focused around $E/q \cong 793$ eV/e mostly only on one energy level. As the solar wind's velocity is relatively constant, essentially it is a huge surge of charged particles. This peak can be attributed to the solar wind, which is the cause of the aforementioned high background counts. Since the TOF analyzer uses carbon foils, at higher rates of flux there are more spurious coincidences that are false counts due to the nature of the carbon foils.

The first species on the left with the highest average flux is hydrogen protons. This species TOF spans from 13 ns to 18 ns and has a large distribution among various energy levels. Broad energy distributions like this correspond to the oscillatory nature of PUIs as well as their wide spread in velocities. As the Sun approaches a solar minimum, hydrogen PUIs are more likely to be detected outside of the focusing cone than in it; production of Lyman alpha particles creates the hydrogen depletion region within the focusing cone. Here plenty of hydrogen can be seen; however, currently, PUI hydrogen and coronal hydrogen cannot be distinguished from one another.

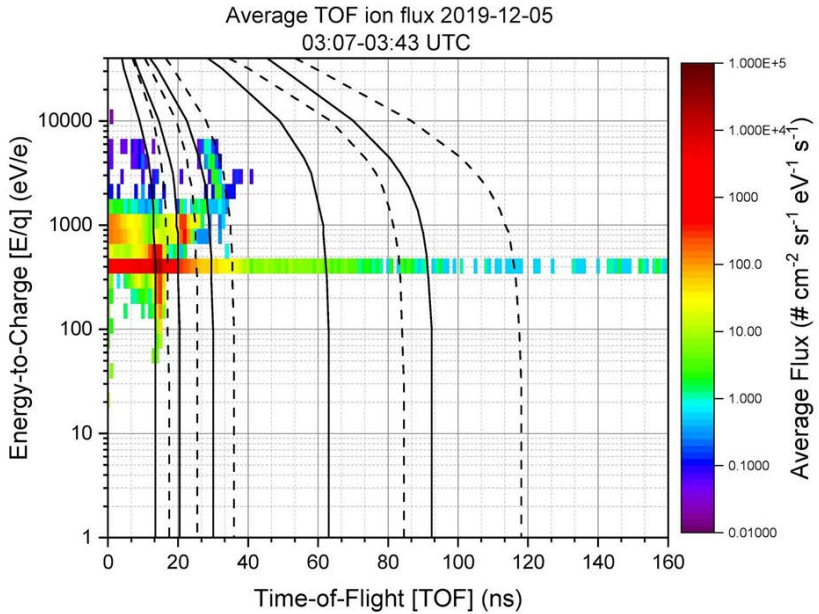


Figure 3: Average time-of-flight (TOF) mass spectrum of the ion flux measured by HPCA on 5 December 2019 03:07-03:43 UTC. Ion species are identified by their TOF and energy-to-charge ratio (E/q). There are 32 E/q levels and flight times up to 160 ns for the TOF. The maximum TOF measurement is 256 ns. The color scale at the left corresponds to the average ion flux measured during this interval. The proton flux is peaked at $E/q \approx 793$ eV/e that corresponds to the peak energy of the solar wind. This is also the reason for the spurious coincidences that stretch out to 160 ns. Each solid-dashed line pair indicates the TOF ranges where each ion species is found. Protons have a broad energy distribution, reflecting the broad PUI velocity range. This broad velocity range occurs because of their oscillatory motion. The set of lines ranging from about 20 ns to 25 ns indicates doubly charged helium that is also known as alpha particles. This is primarily a solar wind product that is focused on a few levels, which indicate the solar wind. The next species is singly charged helium ranging from 30 ns to 46 ns, a well-known product of pick-up helium. Similarly to the hydrogen ions, the singly charged helium has a wide spread in velocities that further confirms that we are detecting pickup helium.

Doubly charged helium (He^{2+}), also known as alpha particles, are the next species. These ions are very finely distributed on a few levels centered around $E/q \approx 800$ eV-1 keV;

this indicates that they are of SW origin. Following He^{2+} is singly charged helium (He^+), which again shows the signature broad energy distribution. Since this distribution doesn't interact with that of the SW, we know that all the flux is from real counts. The flux also cuts off at an energy corresponding to 2x the SW velocity, the tell-tale sign of PUI's. Given that the Earth was in its apogee, which, in turn, means that it was in the helium focusing cone, it is clear that HPCA has detected helium PUIs.

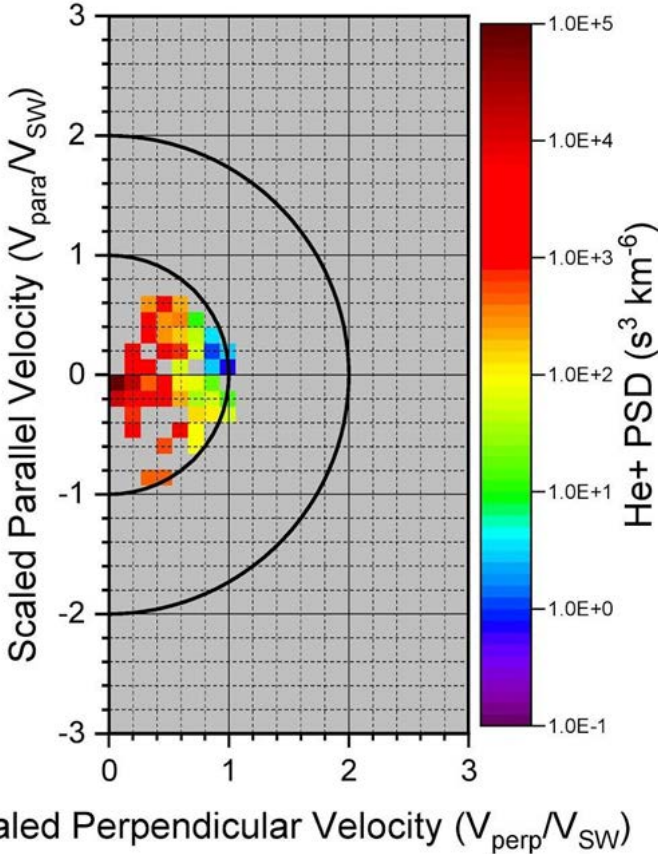


Figure 4: Gyrotropic analysis of helium PUIs for 5 December 2019 03:07-03:43 UTC. This 2D collapse of helium PSD was performed using the process outlined in Gomez et al., (2019). Helium PSD is collapsed into phase-space parcels that have parallel and perpendicular components to the magnetic field. The acquired data is translated into the SW frame and rotated into the magnetic field frame so that the origin is the solar wind velocity. On the vertical axis, the components of the velocities that are parallel to the

magnetic field are plotted. Then, the perpendicular components are plotted on the horizontal axis. Noise contributions from the SW are mitigated by removing the energy steps corresponding to those of the SW (steps 32 -38, seen in Fig. 2). The colored squares represent the PSD contributed at the respective velocity coordinates as seen in the color scale at right. Grey squares indicate true zero PSD measurements. The black concentric contour lines indicate 1x and 2x the SW velocity, in the SW-centered frame, respectively. Since all PSD contributions within the first contour line, after removing SW contributions, we can positively identify these counts as helium PUIs.

3. Conclusion and Discussion

The purpose of this paper is not to prove the existence of PUIs. Instead, its intent is to demonstrate HPCA's capability to fully observe low mass PUIs and their broad velocity distributions with high temporal and spatial resolutions. The MMS spacecraft are already deployed and make frequency forays into the SW environment. Therefore, this research does not impede any already established projects nor incur any additional costs. It also bears mention that the spatial and temporal scales in which HPCA observed PUIs are currently faster and higher resolutions than instruments specifically built to study PUIs. A hallmark of research is performing scientific research with a tool that was originally intended for another purpose. The novel use of the MMS-HPCAs for PUI research is an example of this.

While proving that HPCA is well-suited for this research is important, this is just a stepping stone to bigger and better things. Some goals of this research are what are interstellar pickup ions composed of and the dynamics of their interactions. For the first goal, establishing how to tell the difference between coronal hydrogen and pickup hydrogen is a step in the right direction. Turbulence and its effect on pitch angle scattering will be the key to solve the latter. A far-reaching goal is to determine how the heliosphere interacts with the interstellar medium. More importantly, can these processes be extrapolated to other portions of the galaxy? A primary science goal of the Heliophysics Decadal Survey includes studying the Solar/LISM interaction, which this research can contribute to.

- Schmidt, W. (2019, February 27). SWAN/SOHO Lyman- α Mapping: The Hydrogen Geocorona Extends Well Beyond the Moon. <https://doi.org/10.1029/2018JA026136>
- Burch, J., Miller, G., Santos, A., Pollock, C., Pope, S., Valek, P., & Young, D. (2005, October 03). Technique for increasing dynamic range of spaceborne ion composition instruments. <https://doi.org/10.1063/1.2084867>
- S. A. Fuselier et al., “Energetic neutral atoms from the Earth’s subsolar magnetopause,” *Geophysical Research Letters*, vol. 37, no. 13, 2010, <https://doi.org/10.1029/2010GL044140>
- Gloeckler, G., Möbius, E., Geiss, J., Bzowski, M., Chalov, S., Fahr, H., . . . Zurbuchen, T. (2004, October 18). Observations of the helium focusing cone with pickup ions. <https://doi.org/10.1051/0004-6361:20035768>
- McComas, D., Allegrini, F., Bochsler, P., Bzowski, M., Christian, E., Crew, G., . . . Zank, G. (2009, November 13). Global Observations of the Interstellar Interaction from the Interstellar Boundary Explorer (IBEX). <https://science.sciencemag.org/content/326/5955/959.abstract>
- Möbius, E., Hovestadt, D., Klecker, B. et al. Direct observation of He⁺ pick-up ions of interstellar origin in the solar wind. *Nature* 318, 426–429 (1985). <https://doi.org/10.1038/318426a0>
- Noda H., Terasawa T., Saito Y., Hayakawa H., Matsuoka A., Mukai T. (2001) Observation of the Interstellar Helium Cone by the Nozomi Spacecraft. https://doi.org/10.1007/978-94-017-3230-7_70

- Pollock, C., Moore, T., Jacques, A. et al. Fast Plasma Investigation for Magnetospheric Multiscale. *Space Sci Rev* 199, 331–406 (2016).
<https://doi.org/10.1007/s11214-016-0245-4>
- Vasyliunas, V., & Siscoe, G. (2012, September 20). On the flux and the energy spectrum of interstellar ions in the solar system.
<https://doi.org/10.1029/JA081i007p01247>
- Young, D.T., Burch, J.L., Gomez, R.G. et al. Hot Plasma Composition Analyzer for the Magnetospheric Multiscale Mission. *Space Sci Rev* 199, 407–470 (2016).
<https://doi.org/10.1007/s11214-014-0119-6>

Hardship in the Age of COVID-19: A Case Study of Remittance Inflows from the United States to Rural Communities in Jalisco, Mexico

Camryn Blackmon

Mentor: Larry Hufford, Ph.D.
St. Mary's University, San Antonio, TX

Remittances have unique properties compared to other financial sources as they react resiliently during economic downturns and have become theorized as a tool for sustainable community development. This paper examines how remittances influence sustainable community development in small villages and towns by analyzing workers' remittance income from Texas to households in Jalisco, Mexico. The analysis will consist of comparing rates of remittance flows during the past two global recessions to understand how the current global recession induced by COVID-19 is impacting remittances differently. To understand how remittances, influence sustainable community development, the paper will assess current literature and history recorded. The hypothesis is that the recession caused by COVID-19 will severely impact the livelihoods of migrant workers in destination countries as well as families and communities reliant on remittances in home countries.

Remittances are money sent by migrant workers to their home countries to support their families and communities by providing income that provides essential resources. In the past few decades, remittances have become a significant financial resource in developing countries and communities. Although remittances occur internationally with countries of all levels of income and development, they serve as a critical source of income and financial cause in developing economies. In lower-income countries, remittances are used to fund basic household needs such as food, medical care, housing, and education. They are crucial for the survival of many families and communities.

Remittances are utilized differently in more affluent households. In these cases, the household receiving remittances already has access to basic needs so it can utilize the capital to invest in small businesses and entrepreneurial activities. Recipients in different income brackets use remittances to develop aspects of their community by either investing in their family opportunities or local entrepreneurial efforts and infrastructure. In remitting money, migrants face obstacles in foreign job markets, culture shock, and the difficulty of sending money through financial systems and channels that are safe for the worker and family. As a phenomenon, remittances are unique in that they are solutions for people in need. As they are produced, sent, and utilized directly by people, remittances have exhibited different characteristics to other forms of financial resources of countries, notably with how they react during economic downturns. International institutions and organizations such as the United Nations and World Bank have noted the role remittances play in alleviating poverty and income inequality. As a result, efforts have been put into recording remittance data sent through official channels because they have surpassed international aid and Foreign Direct Investment (FDI) and remain resilient or more durable than other financial resources during economic downturns and times of crisis. The characteristics of remittances in past economic recessions and times of crisis calls into question how remittances will react in the unparalleled situation of the 2020 global pandemic COVID-19. The pandemic [LGH1] has produced a unique situation, unlike other global recessions, as the lives of migrant workers and their families back home are uncertain. Amid the worldwide pandemic COVID-19, states have taken various methods to slow down the spread of the virus and protect citizens. Major economies are suffering due to mass lockdowns and high unemployment rates. The tertiary sector is suffering as hospitality businesses are closed to limit contact. Still, other essential industries have remained open, putting employees and migrant workers at a health and safety risk. Workers are either struggling with unemployment or continuing

to work under unsafe conditions. The harmful implications of COVID-19 could be reversed if inflows of remittances can rebound. For many, this is a loss in income that is negative in the short run but will most likely have long term impacts on the families and communal development.

The flow of remittances to developing countries will have long term negative impacts on the community development of countries due to the ramifications of COVID-19. This paper will provide an overview of issues associated with remittances, including the process of remittances, past economic downturns, and the current COVID-19 crisis. The paper will assess remittances' characteristics by analyzing global financial data of remittance inflows during the past two global recessions to compare periods from the beginning of the pandemic to July 2020. This paper will then detail the global perspective of remittances from current literature on remittance associated with sustainable community development leading into the case study of remittances from the United States to Jalisco, Mexico. In this case study, the paper will evaluate how remittance influences sustainable community development on a smaller scale as well as address specific issues that will arise in that community concerning both residents and migrant workers that remain in the United States.

Literature Review

To assess the common theory that remittances can sustainably develop a community and review how the recession caused by COVID-19 will impact sustainable development and remittance flows, the narratives of migrants and receiving communities will be assessed, as well as global economic data sets.

Remittances and Development

There is an extensive literature debate over whether or not remittances can be used as a tool for sustainable community development. Studies assessing remittances as a beneficial resource of development for home communities include Karsten

Paerregaard's study *Return to Sender: The Moral Economy of Peru's Migrant Remittance*. Paerregaard challenges the impact of remittances on a community by assessing ethnographic data from North and South America, Europe, and Japan and the Peruvian migration model. Most studies and policies rest on assuming that as long as people migrate, the money will keep flowing. This study further investigates this assumption and suggests that remittance flows fluctuate and change size and direction according to the needs of migrants and their relatives. Paerregaard argues that remittances may not be sustainable because they may not continue being sent (Karsten Paerregaard, 2015). Therefore, he calls attention to policymakers and development organizations to facilitate and work to implement migration policies that serve both the economic needs of countries and, specifically, the interests of migrants and remittance dependent communities. It has been found that remittances increase income inequalities within a community, but it has been documented that rural incomes improve relative to urban ones, since remittances are targeted to the predominantly rural areas of origin (Richard C. Jones, 2008). In the study *Migration and remittances during the global financial crisis and beyond*, based on global remittances outcomes and failures of national economic policy to address public needs, it can be concluded that remittance practices are often anti-cyclical and vital responses to economic crises. The authors make the point that remittances should not be assumed to improve the living situation of households because remittances can displace local incomes and increase inequalities, drive consumptive spending, and inflate prices, among other things (Cohen, Jeffrey H.; Ratha, Dilip; Sirkeci, Ibrahim, 2012). Researchers described the result of this situation as harmful for non-migrants' dependent on remittances and caught in a net of consumerism. This literature illustrates that remittances can be unstable, and that governments and international organizations and institutions, should not rely upon or consider remittances as the sole solution for poverty and community development.

International institutions and organizations

According to a World Bank press release, remittances sent globally in 2018 increased by 9.6 percent from 2017, creating a record in the most substantial flows of remittances sent in a year. In 2018, the recorded flow of remittances sent to both developing and developed countries reached \$689 billion surpassing the figure of \$633 billion in 2017. Among countries receiving remittances in 2018, the top recipients were India with \$79 billion, China with \$67 billion, Mexico with \$36 billion, the Philippines with \$34 billion, and Egypt with \$29 billion. In the World Bank Migration and Development Brief 31, it was predicted that low- and middle-income countries alone are expected to receive \$550 billion remittance flows and that the flows will become the most significant external financial resource. The Bank for International Settlements and the World Bank have formed a special task force on international retail payment systems to improve transparency in remittance transactions. They argue that policy responses should facilitate migration and remittances to make the flow of remittances “cheaper, safer, and more productive for both the sending and receiving countries” (World Bank, 2019). These efforts made by international institutions and governments present both problems and possible solutions to remittance, poverty issues, and the need for sustainable community development.

Narratives

Small villages within Jalisco, Mexico have been studied through ethnographic research by Sarah Lynn Lopez with *The Remittance Landscape: Space, Architecture, and Society in Emigrant Mexico* detailing community development's first-hand experiences with remittances from migrant workers and their families. Sarah Lopez traveled to Los Guajes, Jalisco, San Miguel Jalisco, Villa Hidalgo, Jalisco, and Villa Hermosa, Jalisco. Lopez details that returning migrants also known as “hijos ausentes” or absent sons and children. They are treated so because they have given money to the church and fought to improve the livelihoods

of families that remain in the village. The march ends in the community church, where the priest thanks them and acknowledges them as pillars of the community because they have sacrificed their lives to better the community. The rituals Lopez witnessed and detailed exemplify the significant role remittance has within the community and the hardships that both hijos and families endure for quality community development and prosperity. There are also dangers with returning home as knowledge of accumulated wealth by the returned workers and money saved by the receiving household, put a target on families. Community members had informed Lopez of individuals who lived in the U.S. for an extended period and then decided to return only to be kidnapped and murdered along with their children. Vista Hermosa, another town within Jalisco has prioritized community-building efforts to create a sports arena to compete with those prevalent in the U.S. (Lopez, 2011). In Lopez's study, remittances are studied uniquely in contrast to most literature, as the people behind the concept of remittances are brought forward. Their narratives are detailed to portray the meaning of remittances within a community and what sustainable community development looks like based on the priorities of communities and how remitting processes are altering society.

Remittances from a Global Perspective

As a financial resource for countries, communities, and households, remittances are an effort from people to bring in financial resources to their households, ultimately transforming the environment of communities, including social and cultural dynamics. In recent years, the inflow of remittances to developing countries has significantly increased. This phenomenon calls into question the impact communities will have. In 2013, the number of migrants globally was about \$232 million. This number of migrants only represents three percent of the global population, but they remitted reported inflows of \$414 billion to low and middle-income countries, making remittance inflows one of the most substantial capital flows in the world (Karsten Paerrgaard,

2015). Since 2013, remittance flows have increased internationally. They have become part of the mainstream as international institutions have taken initiatives to analyze and record them more efficiently, and governments are attempting to make policies around them. On a global scale, remittances had substantially increased in 2018, when the World Bank reported that global monetary transfers from migrants reached \$689 billion. Since 2018, the World Bank has predicted remittances would continue increasing. Notably, \$529 billion of the overall number of remittances inflows were sent to low-and middle-income countries (Global Remittances Guide Migrationpolicy.Org, n.d.). Following the reported data provided above, it is evident that low- and middle-income countries are the main driving forces behind workers migrating and sending remittances. This portrays that there is a demand for economic resources and opportunities because it is insufficient within villages and city neighborhoods, or, there is great inequality of these resources within high recipient countries. For many migrants, once they relocate abroad they have accessibility to higher wages and a variety of job opportunities, so for many the poverty and inability to provide family outweighs the obstacles of migrating and being away from family and home for extended periods of time. The fact that low-and middle-income countries are receiving the majority of reported global remittances illustrates that they rely on remittances as a financial resource. Remittance flows to lower-income countries makeup up to 6% of their gross domestic product. In low-and middle-income households and specific communities, remittances are used to fund necessities such as housing, consumer goods, education, and healthcare. In contrast, wealthier households that receive remittances can use the money to fund small businesses and entrepreneurial efforts (Dilip Ratha, 2020). Remittances are able to be utilized towards households and the community in various ways for households with diverse economic backgrounds.

Since remittances have become mainstream, the market for processing and sending remittances has grown and diversified.

There are numerous mediums for migrant workers to remit their money and for receivers to claim it. It is important to note there are official channels to remit but there are also unofficial channels. The official channels are handled by traditional banks, credit unions, and specialized money transfer operators. Popular channels that are used include financial institutions such as JP Morgan, Bank of America, and Wells Fargo and specialized money transfer operators include Western Union, UAE Exchange, MoneyGram. The ability to transfer and access funds over online payment systems is creating a cheaper and more accessible process of remitting money. These platforms are becoming more popular especially as they are cheaper than going through most financial institutions and transfer quickly. Sending money online does not require a remitting household to physically seek out a bank.

Depending on the government's policy as well as size and unity of a community, remittances can be directed towards sustainable community development. Remittances are intended to benefit a family, as payments essentially are an investment in the youth of the family, providing them educational, nutritional, and health resources bringing economic security and opportunities to future generations. As individual families are able to become more economically secure governments and international institutions have begun putting efforts into facilitating remittances and creating economic policies around them. Political leaders have attempted to initiate incentives to increase the flow of remittances to use them in a way government officials and policymakers deem productive. These initiatives have included tax incentives, and matching- fund programs to either increase remittance flow or be able to direct them to public efforts (Dilip Ratha, 2020). It is difficult and can often be problematic because remittances are a source of private income. Still, because they are becoming more abundant than other external financial sources, they are viewed as a tool for development. Similar efforts have been seen with the Mexican government since they launched the "3x1 Para Migrantes" or 3x1 program. In the 3x1 program,

remittances are sent through formal Hometown Associations (HTAs) in the United States and are multiplied by municipal, state, and Mexican federal funds for development. For each peso that is sent by migrants and is put to developmental causes for communities, the state and municipal governments add three pesos each. The program was launched in 1998 with help from the United States government. Since 2001, the 3x1 program has been able to leverage \$7.5 million annually that were used to fund 130 regional projects in Mexican communities directly (3×1 Remittance Program | Migration for Development, n.d.).

On the surface, the 3x1 program and other government initiatives seem productive, but it can be problematic as to which communities and people are benefiting the most. In contrast, other initiatives from international institutions and governments aim to make the remitting process transparent and more accessible. As more families within a community become remittance recipients and family members become migrant workers, remittances unintentionally alter the entire community. Remittances become a prominent source of income, and there is a new vision of economic security. However, some negative implications of remittances are home communities enduring the loss of human capital, families becoming dependent on remittances for household income, and increased income inequality in the community. With more individuals in families leaving for opportunities abroad, the labor pool in home communities significantly decrease. Although this is the main point in literature critiquing remittances, it calls into question whether opportunities in the home country were already scarce. If employment that could support an individual and their household were available in the village, town, or city, people would not endure the dangers and expenses of migrating. Before migration increased for remitting in these areas, employment opportunities were not available and/or sustainable enough to provide the communities' basic needs. Since governments do not create more jobs or lose external investments to procure more, remittances often become the only stable income source for the poor. In low-

income households' remittances contribute to the local economy because lower-income households use remittances for consumption rather than investment. These households rely on remittance payments to survive, utilizing payments to fund housing, food, health care, and education, serving as immediate investments into the livelihood and survival of a community. For low-income households, remittances play a critical role, and the loss of these payments can cause immediate harm to families. The critical role remittances play on income for poor households can be interpreted as both positive and negative. From a positive perspective, remittances are not cyclical compared to private capital flows and foreign direct investment. Remittances are also independent sources of income, meaning they are made to meet the household's direct needs and costs. Although remittances have remained resilient and more dependable than other forms of financial resources, for individual families, their dependence can be harmful if the flow of remittances were paused or significantly increased. For example, remittances have proven to have an immediate effect on increasing income inequality within a community since not all families receive remittances.

Characteristics of Remittances in Global Recessions

The most recent global recessions took place between July 1990 - March 1991 and 2007-2009. Both global recession periods had severe economic and financial disruptions internationally, but remittances remained resilient during both diverse periods of economic downturn. The year before the recession period in 1989, global remittance flows were at US\$ 54,749 million, and low-and middle-income countries were receiving US\$ 24,364 million. As the recession period started in 1990, remittances flowed globally to low-and middle-income countries with the total figure steadily increasing to US\$ 64,034 million and US\$ 28,589 million. At the end of 1991, global flows were at US\$ 67,754 million, with low-and middle-income countries receiving US\$ 31,415 million. In 1992, the year after the recession ended, remittances continued to increase (Figure 1).

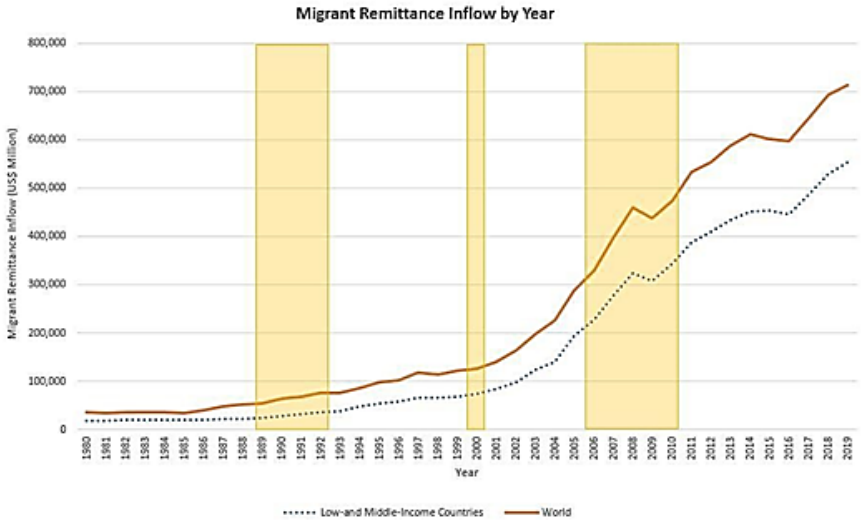


Figure 1 Source: World Bank staff calculation based on data from IMF Balance of Payments Statistics database and data releases from central banks, national statistical agencies, and World Bank country desks. See Migration and Development Brief 28, Appendix A for details.

In contrast, the percentage rate of global GDP growth declined between 1989-1992. In 1989 the global GDP growth was 3.677%, this percentage decreased by 1990 to 1.71%. The GDP further decreased at the height of the 1991 global recession to 1.431%. After the recession ended in 1992, the global GDP growth rate increased to 1.781%(World Bank national accounts data, and OECD National Accounts data files, 2020). Although globally, GDP growth was declining, the rate of global remittances increased.

The next global recessionary period is the most recent global recessions that took place between 2007-2009. The global recession of 2007-2009, also known as the Great Recession, had devastating consequences with many economies still recovering. During this recession, millions of people lost their economic livelihoods, including jobs, housing, and savings. The Great Recession was the most prolonged period of economic decline. It

was most pronounced in the United States, which meant migrant workers living in the United States were vulnerable (Kose et al., 2020). In the early 2000s, remittance inflows to low- and middle-income countries became more than half of the global total, indicating that these countries are the source of the majority of migrant workers abroad and rely upon remittances income. At the beginning of the recession in 2007, remittance flows continue to increase significantly as global inflows were at US\$ 398,837 million, and low-and middle- income flows were at US\$ 278,446 million. In 2008, global flows were at US\$ 460,524, with low- and middle-income countries at US\$ 323,610 million. The overall flow of remittances continued to increase until 2009 when remittance flow decreased by US\$ 16,176 million and overall decreased by US\$ 23, 277 million. After the Great Recession period, remittances begin to increase by around 3.7 % each year (Figure 1). The percentage rate of global GDP growth followed a slightly different pattern than in the previous global recession period. In 2007 the global GDP growth was 4.219% and decreased in 2008 by 2.979% and continued to decrease until the global GDP growth rate was at -1.733% in 2009. After the Great Recession period, the global GDP growth rate increased to 4.317%. In 2007, and 2008 although the global GDP growth rate was decreasing, remittances were increasing until 2009 when remittances decreased significantly along with the global GDP growth rate (World Bank national accounts data, and OECD National Accounts data files, 2020). From this data, it can be concluded that remittance flows do experience declines but they either recover quickly the following year or are impacted very little. The tendency is to think of times of global economic downturns negatively impacting the most vulnerable which would be lower-income communities in home countries as well as undocumented migrant workers employed in hourly wage jobs. Despite preconceived notions, remittances as a financial source

have defied economic downturns and on occasions have actually increased.

In 2020, the world entered a new global recession phase, induced by the coronavirus pandemic, also known as COVID-19. As a global economy, countries are tied together by global supply chains, production, tourism, migration, travel, exports, and imports, etc. With the rise of COVID- 19, a rapidly spreading virus causing a global pandemic, there is the question of how to maintain the elements essential to our global economy while also preventing the spread of the virus while providing adequate healthcare and other necessary resources. The World Health Organization has compiled a timeline of international cases and actions taken by governments and WHO. The first reported cases came from China on December 31, 2019. On January 13, 2020, the first coronavirus case reported outside of China, was confirmed in Thailand. From mid-January to the beginning of March, WHO studied the virus, tracking the spread, and creating joint international missions with global experts from CDC and NIH). On March 11, 2020, WHO declared COVID- 19 as a pandemic (WHO).

The World Bank predicts that remittances will fall by 20% in 2020, precisely due to the fall in wages and employment of migrant workers during the pandemic. As previously stated, remittances are a critical source of income for developing countries and low-income households. During the current COVID-19 crisis, migrant workers and poor families' dependent on remittances are going to suffer more than ever with the decline of an essential financial source that, heretofore, has remained consistent. This illustrates that the global recession induced by COVID-19 is an incredibly unique situation in contrast to the global recessions between 1990- 1991 and 2007-2009. This new global economic recession is causing a host of negative impacts on individuals, communities, and nations. COVID-19 has devastated domestic economies and the international economy,

but specifically is harming the livelihood of migrants in host countries working to earn money to remit to families and communities back home that are suffering from a loss of essential income.

Case Study of Jalisco, México

Mexico is one of the top recipients of remittances. Mexico, as a country, is incredibly vast and diverse with numerous races, languages, cultures, and wealth disparities. Mexico is home to significant vacation and destination sites, with the economy being fueled by tourism, trade, manufacturing, oil, and remittances inflows. Currently, remittances make up 2.3% of the country's GDP, and 1.3 million households in Mexico benefit from the flows of remittances. Mexico mainly receives remittance inflows from the United States due to its proximity. 95.6% of Mexico's remittance inflows come from migrants remitting in the U.S. About 44 % of households within Mexico receive their remittance payments by being directly paid by banking institutions. In contrast, the other 56% receive payments from non-banking institutions that include supermarkets, convenience stores, and drug stores. Almost all of these transactions are made electronically; remittances sent physically in cash makeup, 1.9% of the total sent. The United States and Mexico have significant relations as economic relations with NAFTA, and extensive history of border relations, security, and anti-immigrant rhetoric and policies. In 2017 Pew Research estimated that there were 11.6 million immigrants from Mexico living in the U.S., and about 43% of this population were undocumented (NW et al., n.d.). Presently, the U.S- Mexican border has become a war ground, with militarized security measures, desire for a border wall, and mass detention of migrants creating more risks and complications for migrant workers. Border security and tense politics surrounding immigration have made migrating to the U.S. increasingly dangerous. In 2015, remittances sent to Mexico surpassed income from tourism and oil exports, which are both

significant sources to the Mexican economy (Juan José Li Ng, 2016).

Banco de México is Mexico's central bank, monetary authority, and lender. Since the early 2000s, Banco de México has been working to track remittances by including work with Mexican consulates in the United States to issue migrant identification cards so they can open U.S. bank accounts. According to Banco de México, Michoacán, Jalisco, and Guanajuato are the top and primary states in Mexico receiving remittances. Banco de México reported that Jalisco had received the most remittances in 2020 with US\$ 979.14 million, Michoacán with US\$ 952.98 million, and then Guanajuato US\$ 813.61 million.

Mexico's government has developed programs to utilize the abundance of remittances inflows that go to private household incomes. The government's goal with these programs is to make use of the mass financial resources for community development and projects. As previously mentioned, Mexico's most notable program with remittances is the 3x1 program. The program has been used as an incentive for remittances funds to go through Hometown Associations in the U.S. that comprise migrant workers from similar communities and regions. The 3x1 program has developed building projects and politics that heavily influence the culture of remittances in Mexico. These programs have become a model for other high recipient countries, but the program is controversial for effectively meeting the needs of the community (Lopez, 2009). In Jalisco, a similar project affiliated with Hometown Associations is program Por mi Jalisco programme. The program provides support in investment feasibility studies and grants and credits for migrants investing in their home communities. Hometown Associations organized several community investment projects that donate about \$30 million a year to communities in Mexican states (Orozco, n.d.).

Small villages that receive and rely on remittances in Jalisco include Los Guajes, Jalisco, San Miguel Jalisco, Villa Hidalgo, Jalisco, and Villa Hermosa, Jalisco. Remittances are very critical within these small communities. Going beyond developmental efforts from Hometown Associations and the Mexican Government, migrant workers' direct contributions and their remittances need to be noted. Within these small villages, Men make up a majority of migrant workers that travel abroad. Therefore, village demographics have shifted to being predominantly women and youth. The shift in gender and age demographics has partially influenced the heroic culture around remitting migrants. In these villages, migrant workers are known as "hijos ausentes" or absent sons and children because they no longer reside in the community but contribute significantly. Once individuals decide to migrate and remit from abroad, they immediately put themselves at risk and have separated themselves from their home and family physically and socially. That is why critical community leaders like priests acknowledge and celebrate the return and contributions of migrant workers. When they return for short periods, the community holds parades where the residents celebrate them similar to veterans returning from the war. Once they leave, their role and identity within the community are altered. Although they have taken part in transforming the community and their families for the better, they do not usually get to benefit from life in this new community. When hijos return, they experience a new landscape that often consists of architecture emulating American style and cultural values.

The impact of COVID-19 of migrant workers in Texas from Jalisco, Mexico

In analyzing Lopez' ethnographic research, *The Remittance Landscape: Space, Architecture, and Society in Emigrant Mexico*, it is evident that remittances play an essential

role within economic development and individual household income. However, it also has influenced the functions of society. The coronavirus pandemic has caused mass unemployment within the U.S. and has reported an increasing number of cases internationally. Over 95% of migrant workers remitting are working within the U.S., meaning they are part of the population either unable to work, not receiving a government stimulus check, or being put at risk to continue working to support their life in the U.S. and family at home. In the U.S., immigrants make up about 17% of the labor force. The majority of immigrants work in four major industry groups: healthcare and educational services, recreation and food services, manufacturing, and professional, administrative, management services (national immigration forum). These are all industry groups that are being heavily impacted by COVID-19 policies within the U.S. Most of these jobs are unable to provide remote work, and they involve contact with others. During the other last two global recessions from 1990-1991 and 2007-2009, migrants were able to shift to other industries to meet their needs (Figure 2).

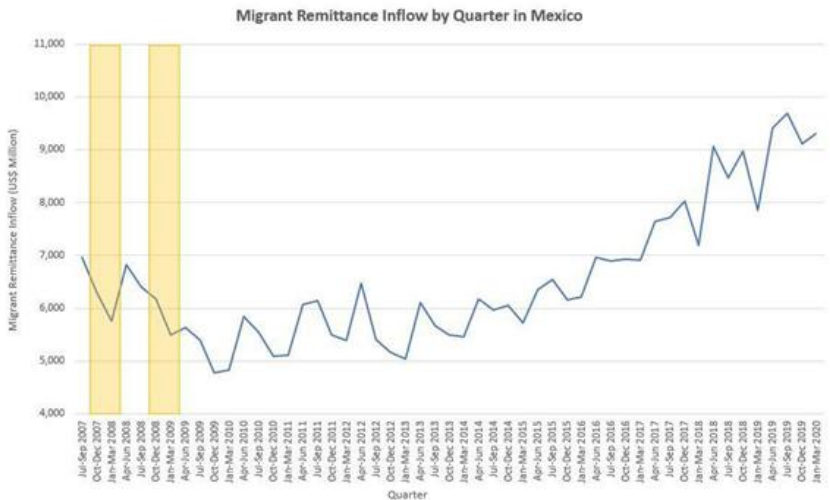


Figure 2 Source: Information Structure Details (SIE, Banco de México)

If a particular industry was suffering, migrants would learn new skills and gain new employment to continue remitting. The pandemic has brought new issues to almost all industries; cities face mass lockdowns and curfews that limit hourly wages or have led to migrant unemployment. Another issue is that industry jobs such as manufacturing have continued without pause, causing many employees to contract the virus. There is an issue with migrant workers being placed in vulnerable situations where they are at risk of catching the virus, then not being able to get adequate healthcare due to lack of health insurance or being undocumented. As a consequence, the households within the community of origin suffer in the short-term.

Remittances to Mexico are predicted to fall by at least 17% in 2020. Currently, the COVID-19 global recession can be compared to the recession of 2007-2009 because there was a significant decrease in remittances being sent during the height and end of the recession period (Juan José Li Ng & Carlos Serrano, 2020). According to past remittance patterns in global recessions, the period begins with an increase because migrant workers are expecting the worst, so they remit more. From January-March 2019, Banco de Mexico reported a US\$ 193.2 million increase of total remittance flows to Mexico and US\$ 86.54 million increase to Jalisco from December 2019 (Figure 2). Following the remittance pattern experienced in the Great Recession, the remittance flow globally would begin to decrease within a year. The World Bank predicts global growth to rebound to 4.2% in 2021 as the global economy will decrease by 5.2% in 2020. This prediction includes some where advanced economies grow 3.9% and EMDEs increase by 4.6%. Another possibility is that the spread of the pandemic increases, causing continued economic downturn and retreat from global trade and supply linkages. This scenario could lead the global economy to decrease by 8% in 2020 (COVID-19 to Plunge Global Economy into the Worst Recession since World War II, n.d.). The global recession

caused by COVID-19 has more significant perceived long-term global economic effects than the Great Recession. The negative implications of COVID-19 on the US economy and health risks directly impact the communities that rely on remittances because these households have lost their primary source of income. The small villages in Jalisco, Mexico, employ remittances for individual households as private incomes and payments go directly to building infrastructure and churches that maintain the community. The decline in remittances to low-income towns and villages will result in food shortages and immediate livelihood needs. Fortunately, when migrant workers learn of possible economic crises, they remit more money. At the beginning of this recession, many households are equipped to survive, but the amount of time they have is uncertain.

Recommendation

After assessing the potential economic consequences on the flow of remittances from the pandemic's recession, it can be concluded that remittances are not a reliable source of income. Although remittances provide numerous households' mobility and community development, the consequences of this source being halted are life-threatening for populations in developing countries and poor communities.

As evaluated from previously mentioned literature, remittances appear to be a plausible solution for improvised communities. Residents have already turned to remittances as a solution for economic hardships. When analyzing the impacts of remittances on the village level, it is apparent that when efforts are dedicated by community members or migrant workers from abroad, the needs are met. The history of government programs attempting to use remittances for public projects and development has proven controversial as the community does not take part in the organization or implantation of these projects. There are also inequalities as to which communities can benefit from specific projects, which ones the government is paying attention to, and

whether members of the community need and want these projects? To answer these questions and assess the puzzling issue of remittances contributions to sustainable development, this paper recommends putting the voices of communities at the forefront. Villagers such as those in Jalisco, Mexico, should take the lead and define what their community needs to develop with the help of international organizations. International organizations can supply guidance and resources that supplement the leadership of community members.

Conclusion

As they are produced, sent, and utilized directly by people, remittances have exhibited different characteristics to other forms of financial resources of countries, notably with how they react during economic downturns. The flows of remittances to developing countries will have long term negative impacts on the community development of countries due to the ramifications of COVID-19. In remitting money, migrants face obstacles in foreign job markets, culture shock, and the difficulty of sending money through financial systems and channels that are safe for the worker and family back home. From the analysis of the two global recessions, it is apparent that remittances have exemplified a consistent pattern of increasing flows at the beginning of the recession period, decreasing at the height of the period, and then bouncing back within a year or two and continuing to increase. With the pandemic's distinctive situation, not only is there an economic crisis, but policymakers need to prioritize the health of people, putting the economy at greater risk.

In the case of Jalisco, Mexico, the majority of migrant workers remitting reside in the U.S. Workers are employed prominently in industries of manufacturing, service, administrative and management, and agriculture. These industries face grave health risks as the jobs require contact and are unable to take place remotely. Another prominent issue with these jobs is that many workers have become unemployed due to businesses having to close for safety measures or not afford to pay

employees. Individuals essential to the livelihood of households in home communities are in immediate risk due to losing their primary source income. However, the lives of migrant workers in host countries face a high risk of contracting the virus and not having the support to receive healthcare. When looking at the issue of remittances in the age of COVID-19, the issue needs to be looked at from both perspectives of migrant workers and households receiving remittances. These are the parties that are suffering the most within this issue, although the country as a whole will lose financial sources and GDP in the long-run, the people involved in the process will suffer immediately.

Overall, this research serves to bring forward the people behind the issue of remittances and the theory of sustainable development. Research must continue on the subject matter with international institutions and organizations continuing to record global remittances inflows and making the remitting process more accessible.

References

- 3 × 1 Remittance Program / Migration for development.* (n.d.-a). Retrieved June 23, 2020, from <http://www.migration4development.org/en/projects/3-%C3%97-1-remittance-program>
- 6A, D., Matthew; Loewenstein, Mark. (n.d.). *How many workers are employed in sectors directly affected by COVID-19 shutdowns, where do they work, and how much do they earn? : Monthly Labor Review: U.S. Bureau of Labor Statistics.* Retrieved June 24, 2020, from <https://www.bls.gov/opub/mlr/2020/article/covid-19-shutdowns.htm>
- Admos O. Chimhowu, Jenifer Piesse, & Caroline Pinder. (2005). *The Socioeconomic Impact of Remittances on Poverty Reduction.* In *Remittances DEVELOPMENT IMPACT AND FUTURE PROSPECTS.*
- Aparicio, F. J. (n.d.). *Collective Remittances and the State: The 3x1 Program in Mexican Municipalities.* 35.

- Buch, C. M., & Kuckulenz, A. (2010). Worker Remittances and Capital Flows to Developing Countries. *International Migration*, 48(5), 89–117. <https://doi.org/10.1111/j.1468-2435.2009.00543.x>
- Cañas, J., Coronado, R., & Orrenius, P. M. (1994). *Explaining the Increase in Remittances to Mexico*. 5.
- Cohen, Jeffrey H.; Ratha, Dilip; Sirkeci, Ibrahim; (2012). *Migration and remittances during the global financial crisis and beyond (Vol. 1)*. The World Bank. <http://documents.worldbank.org/curated/en/701621468149081927/pdf/693130PUB0publ067926B09780821388266.pdf>
- COVID-19 to Plunge Global Economy into Worst Recession since World War II*. (n.d.). World Bank. Retrieved June 24, 2020, from <https://www.worldbank.org/en/news/press-release/2020/06/08/covid-19-to-plunge-global-economy-into-worst-recession-since-world-war-ii>
- Data release: Remittances to low- and middle-income countries on track to reach \$551 billion in 2019 and \$597 billion by 2021*. (n.d.). Retrieved June 23, 2020, from <https://blogs.worldbank.org/peoplemove/data-release-remittances-low-and-middle-income-countries-track-reach-551-billion-2019>
- Dilip Ratha. (2020, February 24). Finance & Development. *Finance & Development | F&D*. <https://www.imf.org/external/pubs/ft/fandd/basics/remitt.htm>
- Elizabeth Grieco. (2004). *What Kind of Work Do Immigrants Do? Occupation and Industry of Foreign-Born Workers in the United States*. Migration Policy Institute.
- Finance & Development*. (n.d.). Finance & Development | F&D. Retrieved June 22, 2020, from <https://www.imf.org/external/pubs/ft/fandd/basics/remitt.htm>
- Global Remittances Guide | migrationpolicy.org*. (n.d.). Retrieved June 22, 2020, from

- <https://www.migrationpolicy.org/programs/data-hub/global-remittances-guide>
- IMF Blog. (n.d.). *The Great Lockdown: Worst Economic Downturn Since the Great Depression*.
- IMF Blog. Retrieved June 7, 2020, from <https://blogs.imf.org/2020/04/14/the-great-lockdown-worst-economic-downturn-since-the-great-depression/>
- Immigrants as Economic Contributors: They Are the New American Workforce*. (n.d.). National Immigration Forum. Retrieved June 24, 2020, from <https://immigrationforum.org/article/immigrants-as-economic-contributors-they-are-the-new-american-workforce/>
- Impact of the Covid-19 Pandemic on Migrants and Remittances to Latin America and the Caribbean*. (n.d.). The Dialogue. Retrieved June 11, 2020, from <https://www.thedialogue.org/analysis/impact-of-the-covid-19-pandemic-on-migrants-and-remittances-to-latin-america-and-the-caribbean/>
- Information structure details* (SIE, Banco de México). (n.d.-a). Retrieved June 7, 2020, from <https://www.banxico.org.mx/SieInternet/consultarDirectorioInternetAction.do?accion=consultarCuadro&idCuadro=CE168&locale=en>
- Juan José Li Ng. (2016, September 14). *Mexico is the fourth largest remittance recipient in the world | BBVA*. <https://www.bbva.com/en/mexico-fourth-largest-remittance-recipient-world/>
- Karsten Paerrgaard. (2015). *Return to Sender: The Moral Economy of Peru's Migrant Remittances* (First edition). University of California Press.
- Koczan and Loyola—2018—How Do Migration and Remittance Affect Inequality.pdf*. (n.d.). Retrieved May 15, 2020, from <https://www-elibrary-imf-org.blume.stmarytx.edu/doc/IMF001/25217-9781484361634/25217->

9781484361634/Other_formats/Source_PDF/25217-9781484363461.pdf

- Koczan, Z., & Loyola, F. (2018). *How Do Migration and Remittances Affect Inequality? A Case Study of Mexico*. IMF Working Papers, 18(136), 1.
<https://doi.org/10.5089/9781484361634.001>
- Kose, M. A., Sugawara, N., & Terrones, M. E. (2020). Global recessions. In *CAMA Working Papers* (No. 2020–10; CAMA Working Papers). Centre for Applied Macroeconomic Analysis, Crawford School of Public Policy, The Australian National University.
<https://ideas.repec.org/p/een/camaaa/2020-10.html>
- Lopez, S. L. (2011). *The Remittance Landscape: Space, Architecture, and Society in Emigrant Mexico* [UC Berkeley]. <https://escholarship.org/uc/item/4s87242n>
- Maimbo, S. M., & Ratha, D. (Eds.). (2005b). *Remittances: Development impact and future prospects*. World Bank. *Migrant Remittances Will Plummet. Here Is What That Means for Global Development*. (n.d.). Center For Global Development. Retrieved June 8, 2020, from <https://www.cgdev.org/blog/migrant-remittances-will-plummet-here-what-means-global-development>
- Ng, J. J. L., & Serrano, C. (2020). *Remittances to Mexico could fall by 17% in 2020 and recover between 2023 and 2028 due to the Covid-19 economic crisis*. 6.
- Orozco, M., & Lapointe, M. (2004). Mexican Hometown Associations and Development Opportunities. *Journal of International Affairs*, 57(2), 31–49.
- Regional Oral History Office - University of California, Berkeley. (n.d.). *1990-92 Early 1990s Recession—Timeline—Slaying the Dragon of Debt*. The Bancroft Library. Retrieved June 24, 2020, from <https://bancroft.berkeley.edu/ROHO/projects/debt/1990srecession.html>
- Remittance Recipients in Mexico / Publications*. (n.d.). Retrieved May 31, 2020, from

- <https://publications.iadb.org/publications/english/document/Remittance-Recipients-in-Mexico.pdf>
- Remittances*. (n.d.). Migration Data Portal. Retrieved June 1, 2020, from <http://migrationdataportal.org/themes/remittances>
- Remittances: Mexico's highest source of income*. (n.d.). Retrieved June 8, 2020, from <https://theguadalajarareporter.net/index.php/columns/columns/ed-tasca/51449-remittances-mexico-s-highest-source-of-income>
- Richard C. Jones. (2008). *Remittances and Inequality: A Question of Migration Stage and Geographic Scale**. <https://doi.org/10.1111/j.1944-8287.1998.tb00102.x>
- Sending money from United States to Mexico—Remittance Prices Worldwide*. (n.d.). Retrieved June 22, 2020, from <https://remittanceprices.worldbank.org/en/corridor/United-States/Mexico>
- The Great Recession | Federal Reserve History*. (n.d.). Retrieved June 24, 2020, from https://www.federalreservehistory.org/essays/great_recession_of_200709
- The Recession of the Early 1990s*. (n.d.). Study.Com. Retrieved June 24, 2020, from <https://study.com/academy/lesson/the-recession-of-the-early-1990s.html>
- The World Bank. (2019, April 8). *Record High Remittances Sent Globally in 2018* [Text/HTML]. World Bank. <https://www.worldbank.org/en/news/press-release/2019/04/08/record-high-remittances-sent-globally-in-2018>
- WHO Timeline—COVID-19*. (n.d.). Retrieved June 24, 2020, from <https://www.who.int/news-room/detail/27-04-2020-who-timeline---covid-19>
- World Bank national accounts data, and OECD National Accounts data files. (2020). *GDP (current US\$) | Data*. <https://data.worldbank.org/indicator/ny.gdp.mktp.cd>

World Bank Predicts Sharpest Decline of Remittances in Recent History. (n.d.). [Text/HTML]. World Bank. Retrieved May 31, 2020, from <https://www.worldbank.org/en/news/press-release/2020/04/22/world-bank-predicts-sharpest-decline-of-remittances-in-recent-history>