An In-depth Analysis of the Connection Between Asthma and Emissions in Southwest Indiana

Research Question:

What is the relationship between greenhouse gasses emitted from industrial sites in Southwest Indiana to the prevalehce of asthma in youth ages 5 to 17?

Subject: Sciences: Environmental Systems and Societies

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Introduction

Ever since the era of industrialization, the emission of toxins into the air has continued to prevail to boost societies' needs for progression. However, with this comes the consequences of pollutants in the air that creates a wide range of effects on the environment, and especially humans. This study will look more in-depth at the effects of pollutants, like NO_x and SO_2, on the respiratory system in children. Most emissions of these pollutants that will be studied are emitted mainly from coal-fired power plants as well as some other industrial sites that combust fossil fuels. Jamie Hopkins who is a senior editor and author at The Center for Public Integrity reported on a very important issue regarding the state of coal-fired power plants. She wrote an article saying that in the United States, there are a total of 22 coal-fired power plants that are dubbed "super polluters" because of their large emissions of greenhouse gasses and toxic pollutants. Furthermore, four of these "super polluters" lie within a 30-mile radius of the city of Evansville in Southwest Indiana (Hopkins, 2016). However, another large contributor to these pollutants is automobiles, which can complicate studies that strictly try to focus on the effects of these plants. With pollutants in the atmosphere, health problems begin to arise, especially in the respiratory system. Therefore this study will analyze the relationship between pollutants and asthma in children in Southwest Indiana. Ever since the start of the modern environmental movement in the 1950s, the mitigation of pollution, in general, has been an overarching topic that is not something that lacks data. Therefore an increasing amount of epidemiological studies have been able to support the topic and the research question. **What is the relationship between greenhouse gasses emitted from industrial sites in Southwest Indiana to the prevalence of asthma in youth ages 5 to 17?**

Literature Review

The presence of criteria pollutants creates health effects like asthma, especially in children. There is a multitude of epidemiological studies that look into the relationship between criteria air pollutants like NO_x, SO_2, CO_2, PM2.5/10, and ozone. For example, Janice Kim (2004) described the major sources and implications of these criteria air pollutants and their relationship to health. In this report, the author not only looks at the causes and effects of these pollutants but also looks at the specific effects on children. She mentions how the criteria pollutants that include ozone, sulfur dioxide, particulate matter, and nitrogen dioxide, have impacts like respiratory tract illnesses, asthma, and decreased lung function (Kim, 2004). This journal's primary purpose is to serve as an information depot about these criteria air pollutants, drawn from 100 sources for information. The author also noted that because children are outside more often than adults, they are more susceptible to the effects of air pollutants while their alveoli are still developing (Kim, 2004, p.1). This is significant to the problem of asthma because children would be in more contact with SO_2 or NO_x and therefore have a higher chance of developing respiratory issues. The main limitation of this article is that it is not primary research, but an advantage is that it includes very detailed information about the pollutants and their effects. Similarly, a study done by Deger, Plante, Jacques, Goudreau, Perron, Hicks, Kosatsky, and Smargiassi (2012) examined the association between exposure to sulfur dioxide emissions from smokestacks and the prevalence of asthma among children. The method included using data from a respiratory health survey for children in Montreal, ages six months to 12 years of age. In this journal, the authors concluded that there was a relationship between the emission and exposure of sulfur dioxide and the prevalence of asthma in children who lived in proximity to the

refineries (Deger et. al, 2012). This supports the idea that the presence of pollutants affects children and the idea that there also is a relationship to health issues like asthma. The main limitation of this study was that there was a lack of availability for information regarding the children's residency. Another limitation is that the data is pulled from a survey method which might not always be the best way to represent the actual respiratory issues in the community. But an advantage of this study was that it included primary research and it was also done outside of the US which diversifies the areas in which data is being collected from. Additionally, another article by Koren (1995) analyzes and describes the association between different criteria air pollutants and asthma. Koren noted that there is increasing evidence to support the idea that asthma prevalence has heightened in areas like the U.S., parts of Europe, New Zealand, Australia as well as other countries (1995, p. 2). A limitation of Koren's article though is that there was no primary data, but an advantage was she used multiple credible sources to back her claims throughout the article. However, Koren also noted in the article that not all of the criteria pollutants affect asthma (1995 p. 3). This goes to show that not all of the emissions that are released from point sources have a large effect on people with health conditions or vulnerable immune systems.

Similarly, in a study done by Mustapha, Blangiardo, Briggs, and Hansell, they investigated associations between respiratory health and outdoor and indoor air pollution in schoolchildren 7–14 years of age in low socioeconomic status areas in the Niger Delta. The authors concluded that the data showed a small number of children with asthma and the connection between asthma and traffic pollution was not shown (Mustapha et. al, 2011, p. 5). However, a limitation of their study was that they believed that there were certain factors that might have been underestimated which may have revealed different results. The conclusion is

that there is a multitude of studies that show that there's a relationship between the number of asthma cases and the corresponding pollutants but there are also a few studies that draw inconclusive.

However, this relationship between emissions and asthma and other respiratory issues is one of the main foundations of this study. It is important to understand that in an extremely controlled environment, emissions do affect respiratory health. Nevertheless, to what extent do the emissions in the non-controlled environment of Southwest Indiana affect the asthma prevalence is the question that is being asked here, knowing that there is a relationship between the two variables in a controlled area.

Despite the relationship between asthma and pollutants, variables such as proximity to the point-source pollution play a significant role in its effect. Proximity is a variable that is used in a lot of studies surrounding this topic. Additionally, Currie, Davis, Greenstone, and Walker (2015) analyzed a rich dataset of the location and economic activity of industrial plants in five large states in the US. The authors concluded the ambient air quality is only affected within one mile of the industrial plants, and therefore the health effects of the emissions should be most prevalent in this range (Currie et. al, 2015, p.30). This means that after 1 mile, the ambient air quality was not affected by the pollutants emitted from the power plant. This was accomplished by looking at housing units around power plants and analyzing the health of children while taking into consideration the distance from the plant. One of the only limitations mentioned in this journal was the limitation of the housing data which contained very little information about the characteristics of the housing unit; however, this would still not change the outcome that they concluded regarding the proximity to the power plant. The advantage of this journal is they used

primary data and there were few limitations. Similarly, Liu, Lessner, and Carpenter (2012) studied proximity to a power plant and the hospitalization rate for respiratory disease. This was done by estimating hospitalizations due to asthma along with other respiratory issues from hospitalization data from 1993 to 2008. They concluded that exposure to air pollution generated from fuel-fired power plants and the combination of volatile compounds from hazardous waste escalated the risk of hospitalization for respiratory diseases (Liu, 2012, p.1). This shows that the proximity to the plant does in fact increase the risk of respiratory disease. However, a limitation was that the height of the smokestacks may be migrated contaminants further than the geographic range that was being studied (Liu, 2012, p. 3).

Additionally, in a study done by Hii, Beyer, Namin, Malecki, Schultz, and Rublee (2021), the authors looked once again at the proximity variable in regard to respiratory issues. And they concluded that the adults living in proximity to one of the 11 coal-fired power plants that were being studied had worse pulmonary function than the adults that lived 35 kilometers (roughly 22 miles) away from the plants (Hii et. al., 2021, p. 1). Once again, there is a relationship shown between the proximity of the coal-fired power plant and the rate of respiratory diseases. No limitations were mentioned by the author, but an advantage of this study is that the authors included a large sample size of adults for this study to make the data more reliable. On the other hand, a study by Hendryx, Hurka, Ahern, and Putman (2012), examined how rural areas adjacent or nonadjacent to urban population centers vary in measures of air quality. They concluded that there was not much to differentiate the rates of asthma between rural and urban areas (Hendryx et. al, 2012, p.3). This shows that the pollution from urban areas created by traffic and other variables did not affect the asthma cases in rural areas where there would be a lower ambient air quality level because of the reduced population. A limitation of the

article was that the study was limited to a county-level assessment of the air pollution measured rather than the state level. An advantage however is that this is a unique article in that it looks at rural and urban comparisons and how they might affect each other. Conversely, Pfeiffer (2017) examined the connection between exposure to coal ash in homes and asthma in children ages 6-14, the author concluded that the data was inconclusive for the analysis of proximity to coal ash sites and asthma (2017, p. 52). However, a limitation to this that the author noted was that there were small sample sizes which could have accounted for the inconclusive results. And in conclusion, the majority of the journals suggest that proximity to plants or point-source pollutants will result in an increased risk of respiratory diseases like asthma although some journals are inconclusive about their results.

For this study, proximity and distance are one of the most important factors for studying the relationship between asthma and emissions in Southwest Indiana. The proximity of the coal-fired power plants in Southwest Indiana defines the uniqueness of the situation with asthma in this area. Therefore it is important to take into account proximity as a factor contributing to possible asthma. However, because of the source of the data for this experiment, the actual proximity of the patients does not matter. Rather, just that the patients with asthma resided in the Southwest region, showing that they may have been exposed to emissions from these power plants in the region.

The implementation of technologies and or the reduction of emissions is beneficial for the health of people. In an article by Schneider (2000), he looks at the reduction of power plant emissions and the effects of doing so. The use of emissions modeling was used to simulate how this reduction of emissions might affect health. And Scheider concluded that a reduction in

emissions did have a relationship with health benefits (2000, p. 61). One of the main limitations of this study, of the benefits analyses, is the inability to quantify many of the PM adverse effects. Similarly, Markandya, Armstrong, Hales, Chiabai, Criqui, Mima, Tonne, and Wilkinson (2009) assessed the changes in particle air pollution emissions and consequent effects on health that are likely to result from greenhouse-gas mitigation measures in the electricity generation sector in the European Union. They concluded that there were benefits from the decarbonization of electricity production (Markandya et. al., 2009, p. 1). The author mentioned no limitations, but the journal is credible and is peer-reviewed, and contains solid primary data. Similarly, Shindell, Faluvegi, Seltzer, and Shindell examined how a reduction in carbon dioxide results in health benefits. And they concluded that the decrease in air pollution resulted in a total of 153 ± 43 million fewer premature deaths globally (Shindell et. al., 2018, p. 1). The author mentioned no limitations however these results show a significant change in the global community if there was a reduction of carbon dioxide, saving lives. Although this may be true, in an article by Semple, Ochieng, Juvekar, Armah, Luginaah, Emina, and Quansah (2017), the authors determined if household air pollution interventions were associated with improved indoor air quality in households, and they found their conclusion to be inconclusive. The authors did note that there was limited evidence that current data shows health benefits for household air pollution interventions. Also, He, Liu, He, and Zhou (2019) examined the relationship between air pollution and urban forms. The use of a quantitative model which would represent this urban form was used to accomplish this goal. And they concluded that the empirical analysis of the urban form showed that it improved or degraded urban air quality which makes the study inconclusive (He et. al., 2019, p. 1). This shows that the relationship between an urban area and the pollutants that inhabit that area may not be related. Therefore, the addition of new

technologies to reduce pollutants or the reduction of pollutants may not be dependent on location unless it was specifically at a power plant. The authors of this journal mentioned no limitations that would affect this outcome. However, an advantage of this article is that there is a unique perspective for this journal in which the characteristics of the urban area were taken into account. In conclusion, like the other knowledge claims, the majority of the articles indicated a relationship between the reduction of pollutants and health benefits with the exception of a few articles that come out inconclusive and might require more research to get a definite answer.

But it is important to note that current coal-fired power plants across the U.S. do include technologies that attempt to reduce their emissions of pollutants like NO_x and SO_2. To what extent these power plants have similar technologies is unknown with having to conduct further research. This therefore could impact levels of emissions between the four power plants in Southwest Indiana.

Method Section

The method chosen for this paper is that of secondary research and data collection. This method was chosen over primary research and data collection because a wide variety of data already collected for this topic is present. As the scientific field increases its knowledge about the environment and how we interact with it, more epidemiological studies have proved sufficient and reliable. Governments have also conducted large data surveys on different topics which provides the basis for this research paper. This is one of the advantages of using secondary research as a method because the time-consuming part of collecting data is already established. Additionally, the sources chosen for data and information are reliable and have been peer-reviewed. However, one of the limitations of this study is that there is no attempt to make a

breakthrough in the scientific field; but the aim is to draw a conclusion on how emissions from power plants in Southwest Indiana affect the hospitalization asthma rates. Additionally, the resources needed to conduct primary research with collected air data would have been time-consuming and could be expensive. The implementation of the secondary data and the interpretation of that data will use already credible studies as a backbone for the interpretation. Using governmental information from sources like the Indiana Department of Health Stats and the Power Plant Data Viewer from the Environmental Protection Agency (EPA) will allow for data interpretation between emissions of NO_x, SO_2, and the number of people hospitalized for asthma in specific Indiana counties. This possible correlation will be analyzed through statistical testing that will determine whether or not the independent variable of asthma hospitalizations has a correlation to the emissions of pollutants from coal-burning power plants. This study will be replicable due to its reliance on public data along with the use of a common statistical test.

Data

As previously mentioned, data has been collected from governmental databases such as the Power Plant Data Viewer from the EPA and the Indiana Department of Health Stats Explorer which gave state government-collected data on asthma hospitalizations. Two types of asthma cases were collected from the IDOH which included both emergency department visits due to asthma and inpatient hospitalizations due to asthma in children. Both of these types of hospitalizations were chosen because in sum they might better represent the actual number of asthma cases among children in these Southwest Indiana counties.

Table 1: Emergency department visits due to asthma in children 5-17 in Southwest Indiana by county by year with the total cases per year

Year	Dubois	Gibson	Pike	Posey	Spencer	Vanderburgh	Warrick	Summation of Cases
2009	23	37	0	13	12	205	47	377
2010	17	39	6	6	12	220	54	354
2011	19	34	5	12	12	189	51	322
2012	0	38	0	10	15	212	43	318
2013	0	28	0	12	12	199	29	280
2014	0	41	0	6	14	252	31	344
2015	0	29	0	6	16	196	39	286
2016	0	25	0	8	9	201	39	282
2017	0	18	0	8	0	170	40	236
2018	0	13	0	5	9	183	20	230
2019	7	14	6	5	8	142	21	203

This data was obtained from the IDOH and per their data collection methods, any year in which data was less than 5 emergency department visits, it was suppressed 0. The summation of the cases was also chosen because when doing statistical testing, the sum of the cases best represented the area for each year.

Table 2: Inpatient hospitalizations due to asthma in children ages 5-17 in Southwest Indiana by county with the total cases per year

Year	Dubois	Gibson	Pike	Posey	Spencer	Vanderburgh	Warrick	Summation of Cases
2009	7	0	0	0	0	22	7	36
2010	0	8	0	0	0	24	0	32
2011	6	7	0	0	0	18	6	27
2012	0	0	0	0	0	20	5	25
2013	0	0	0	0	0	16	0	16
2014	0	0	0	0	0	18	0	18
2015	0	0	0	0	0	23	0	23
2016	0	0	0	0	0	13	0	13
2017	0	0	0	0	0	14	0	14
2018	0	0	0	0	0	11	0	11
2019	0	0	0	0	0	15	0	15

Please note once again that even though a data count of "0" appears for the inpatient hospitalizations, that does not necessarily mean that there were no cases, the IDOH suppresses data of a count of 5 or less. Also, note that the reason there is less data for inpatient hospitalizations is that a patient admitted into a hospital for asthma would be more severe compared to an emergency department visit where the patient would be able to leave afterward.

Table 3: SO_2 emissions in tons by year on select coal-fired power plants in Southwest Indiana with summation of emissions

Year	Gibson Generating Station	A. B. Brown Generating Station	Alcoa Power Generating	Rockport Generating Station	Summation of Emissions
2009	20,942	5,778	3,382	54,796	84,898
2010	21,874	5,293	4,469	54,242	85,878
2011	18,987	6,233	4,674	56,733	86,627
2012	22,447	7,091	5,170	54,390	89,098
2013	20,669	6,816	5,708	51,636	84,829
2014	22,055	8,080	4,993	54,979	90,107
2015	16,098	6,942	2,907	29,889	55,836
2016	14,963	3,855	3,542	24,341	46,701
2017	13,648	3,114	2,312	20,784	39,858
2018	16,213	3,528	2,815	21,241	43,797
2019	9,666	3,957	648	14,341	28,612

Also, note that the specific power plants are a subcategory used to break down the total emissions in Southwest Indiana for the specific pollutant of SO_2 and the total can be represented by the total summation of the emissions.

Table 4: NO_x emissions in tons by year on select coal-fired power plants in Southwest Indiana

Year	Gibson Generating Station	A. B. Brown Generating Station	Alcoa Power Generating	Rockport Generating Station	Summation of Emissions
2009	9,569	1,721	9,912	19,762	40,964
2010	12,018	1,698	9,319	20,545	43,580
2011	15,024	1,771	11,217	19,809	47,821
2012	12,643	2,121	10,692	21,644	47,100
2013	11,397	1,805	9,952	17,201	40,355
2014	14,292	2,867	10,780	19,726	47,665
2015	10,834	2,139	10,440	13,922	37,335
2016	13,190	1,694	6,837	12,888	34,609
2017	11,385	1,605	4,149	11,261	28,400
2018	10,256	2,128	8,043	8,741	29,168
2019	8,121	2,424	3,136	6,093	19,774

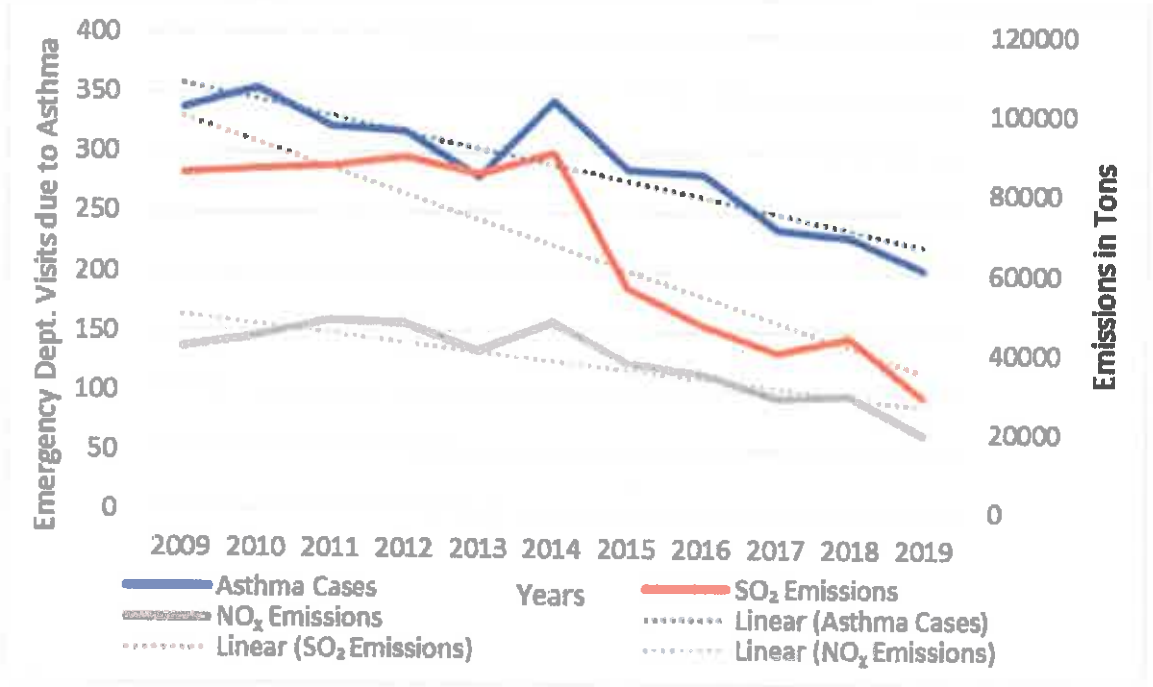
Table 5: Pearson's r correlation test

Emergency Department cases compared to emissions		
	NO_x	SO_2
R-Value: r(20)=	0.92	0.90
Inpatient Hospitalizations cases with emissions		
	NO_x	SO_2
R-Value: r(20)=	0.60	0.67

A Pearson's R test was run to find the correlation between the two different types of asthma cases and the emissions of NO_x and SO_2. For emergency department visits, there was a high

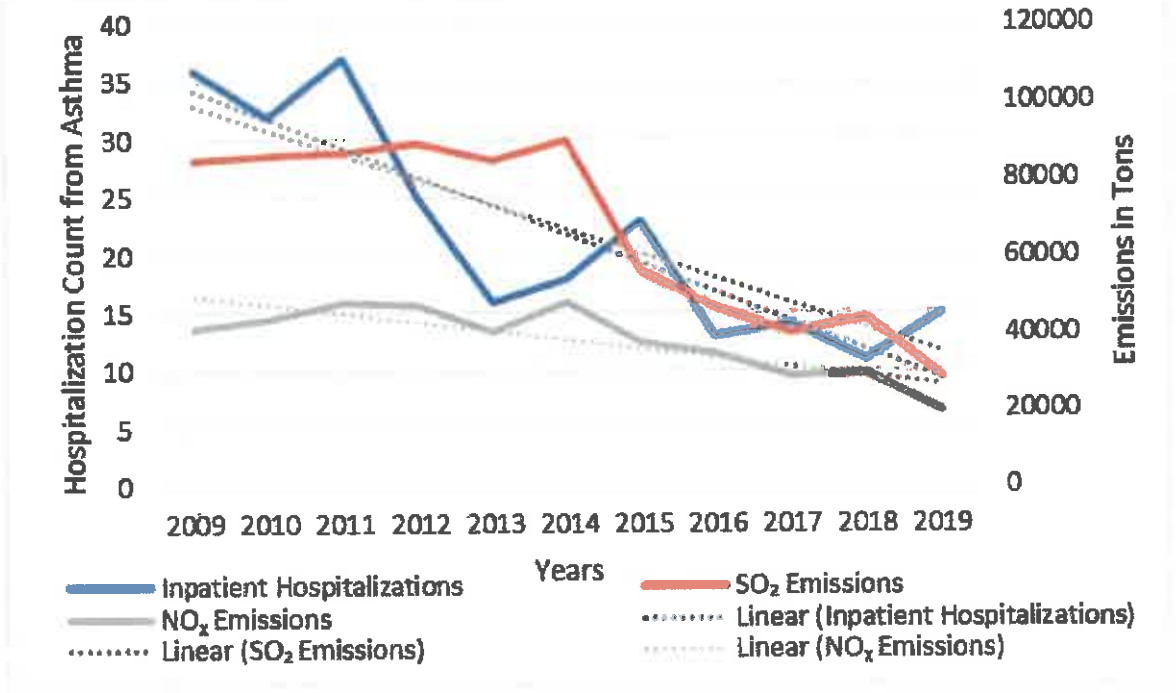
correlation with both pollutants with a probability of $p<0.005$. With inpatient hospitalizations, there was less of a correlation, but still, r values denoted a positive correlation with again a $p<0.005$ probability.

Graph 1: Asthma count for emergency department visits and inpatient hospitalizations due to asthma in children ages 5-17 compared to SO_2 and NO_x data from Southwest Indiana power plants from 2009 to 2019



Note here that as time passes, emissions of SO_2 and NO_x are reduced along with the general trend of the emergency department visits in children, 5-17.

Graph 2: Inpatient hospitalizations due to Asthma in children ages 5-17 compared to SO_2 and NO_x emissions from power plants in Southwest Indiana from 2009 to 2019



Note that because the inpatient hospitalization rates were less common in Southwest Indiana than the emergency department visits, a small change in hospitalizations can create a large change on the graph.

Conclusion

When the two types of asthma cases were combined with emissions to form Graphs 1 and 2, there has been an overall decrease in both emissions and asthma cases since 2009. And when combined with the use of statistical testing, there is evidence of a positive relationship between emissions emitted from industrial sites and children with asthma in Southwest Indiana from 2009

to 2019. As the correlation tests implied, with the decrease in emissions, there is a high probability that asthma cases will also decrease and vice versa.

Discussion and Evaluation of the Conclusion

Because of the very specific scope of this paper, the conclusion, therefore, provided very specific implications and results for the Southwest Indiana region. Although studies have been conducted on the effects of coal-fired power plants and other emitting areas on asthma in people, there have been no studies conducted on this specific scale. Looking solely at four coal-fired power plants in seven counties in Southwest Indiana can give regional insight into the effects of a concentrated amount of pollutants in one area and the effects of such. Although both asthma numbers and the number of emissions did both have what appeared to be a relationship as shown in Graphs 1 and 2, statistical testing was required to indicate whether or not there was a correlation between the two variables. And in conducting a Pearson's Correlation Coefficient test, a positive correlation was revealed for both Emergency Department Visits and Inpatient Hospitalizations with the emissions as shown in Table 5. Despite both sets of asthma numbers having positive correlations with the emissions, the Emergency Department Visit cases have a significantly higher R-value, showing a strong positive correlation. This stronger correlation was most likely due to the higher prevalence of Emergency Department Visits compared to the Inpatient Hospitalizations shown in Tables 1 and 2. The data that was collected from the governmental websites were considered sufficient due to their credibility and the amount of data used. It was also sufficient enough because the statistical tests were able to be performed to yield the correlation results.

However, there are some limitations to this conclusion about emissions and asthma in Southwest Indiana. One of the biggest limitations is the focus on only one variable that could possibly create this correlation between the two variables. Coal-fired power plants are not the only factor that can contribute to asthma. This is therefore one of the limitations to the statistical testing as well. The Pearson's r test merely looked at to what extent did the asthma cases correlate to only the emissions from the four power plants. Other factors include climate, other polluting sources like automobiles, and other internal combustion engines, along with things like emigration or immigration. This study did not look at the composition of the asthma cases; for example, whether or not a person moved into the Southwest Indiana region with a previous history of asthma and went to the hospital or emergency department for their condition. Because of this, there is uncertainty revolving around the extent to which the relationship between asthma cases and emissions is valid. Although this uncertainty is a limitation, it is unlikely that the findings of the paper were significantly skewed due to population changes. And the last limitation of this paper is that only a relationship was established between the two variables. To grasp causation, isolated experiments would have needed to be done to establish if the emissions caused the asthma cases in Southwest Indiana. If causation was established, the implications of such results would be more impactful.

Despite these limitations, there are things that highlight the importance of these findings. As briefly mentioned, the use of governmental databases provided this study with seemingly credible data. The credibility of these databases is built upon the already established resources and technology that the government has. For example, the ability of the EPA to monitor emissions data from coal-fired power plants is going to be more credible than if the method of this paper was primary data collection for emissions. Another advantage of the conclusion

revolves around the niche situation with Southwest Indiana. Because there was such a high concentration of these coal-fired power plants within one area, the effects of such would be greater than if just one power plant was being studied for its effects. Therefore the results of the study epitomize this relationship between asthma and emissions.

Implications

With these results bring the implications of the study on both the regional and national levels. Though causation was not tested for, the positive relationship that was established between emissions and asthma in Southwest Indiana does yield a level of implications. Through statistical testing, these positive relationships indicate that there is a high likelihood that as emissions continue to decrease, so will asthma cases. And with this high concentration of coal-fired power plants in this one area, the regional impacts of these reductions could mean a significant increase in overall health for those affected by emissions. Therefore a push for more legislation that focuses specifically on this topic of reducing emissions even further could possibly benefit overall health. If a broader scope focuses on the national level in terms of this legislation, there could be larger impacts on health nationwide. If, for example, a federal law was passed that required the implementation of technologies or the reduced use of fossil fuels for power generation, the strong positive correlation from the statistical tests would suggest that in at least Evansville, asthma cases would be reduced. Of course, without studying other areas of the United States and the relationship between asthma and emissions in the different geographic regions, the same factors that might affect asthma the most in Indiana might not be the same. Additionally, this supports The Precautionary Principle in the scientific field. To further limit the possible health concerns resulting from the emissions, the continued effort of governmental

intervention in reducing these emissions is the main solution to the problem. With the growing knowledge of this relationship between emissions and asthma and other health concerns, the more time passes without adequate legislation, the number of health concerns will not change. Nevertheless, the implications require further study of this relationship regionally and nationally to determine the extent to which mitigation would be effective. All in all, this paper has been able to find a positive relationship between asthma cases and emissions in Southwest Indiana in children ages 5-17.

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Novel Approach Synthesis of Acetylsalicylic: Application to Opioid Epidemic and Environment

Research Question: to what extent can acetic anhydride be replaced with an alternate reactant in the synthesis of nonsteroidal anti-inflammatory drugs without negatively affecting purity, yield, and cost?

Subject: Chemistry

Word Count: 3,897

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1. Introduction:

The opioid epidemic has reached alarming levels and was recently declared a national public health emergency (Gostin 2017). Due to the addictive nature of opioids, an estimated 25 percent of patients prescribed opioid painkillers misuse them. The opioid epidemic encompasses a large problem that incorporates a broad variety of substances, which includes prescription painkiller opioids, synthetic opioids, and heroin. Although stringent restrictions on prescription painkiller opioids have been enacted, there have been no improvements in the usage and subsequent overdoses of street available drugs. According to the Center for Disease Control (CDC) and Prevention, use of street available opioids has doubled and deaths from overdose have quadrupled since 2002, with an estimated 3.3 million users in the United States alone. Furthermore, as additional restrictions are placed on prescription painkiller opioids, the usage of street available drugs—primarily heroin—increases dramatically due to more convenient access ("vital signs" 2015). A report by the CDC recommended post addiction methods of control such as recognizing symptoms of opioid addiction, analyzing the effects, and devising treatment plans, however, the report also indicated that minimizing access of precursor chemicals to clandestine producers is a viable method of reducing the number affected by opioids. The federal government has followed suit and has named acetic anhydride a List II Precursor Chemical. According to the United States Drug Enforcement Administration (DEA), this provides a system of regulatory controls and criminal sanctions to address both domestic and international diversion of important chemicals without interrupting access to chemicals destined for legitimate commerce (*"List I and List II Chemicals" 2016*). Although these restrictions mitigate access to acetic anhydride from illegitimate purchasers, a majority of the acetic anhydride used for heroin

production comes through legitimate purchases from large chemical manufacturing facilities that are registered but are diverted by rogue importers ("Heroin production and precursors" 2016). The two foremost legitimate users of acetic anhydride are manufacturers of acetylsalicylic acid (the active ingredient Aspirin™) and cellulose acetate. If the requirement of acetic anhydride for the synthesis of Aspirin were not needed, the total circulation of acetic anhydride would drastically decrease, reducing production and consumption of heroin. This leads to the question: **to what extent can acetic anhydride be replaced with an alternate reactant in the synthesis of nonsteroidal anti-inflammatory drugs without negatively affecting purity, yield, and cost?**

2. Background Literature Review

Alternate reagents to synthesize acetylsalicylic acid (ASA) have been considered though they do not have the yields required for successful adoption by the industry. Fahey, Dineen, & Henain (2016), looked at alternate ways to synthesize acetylsalicylic acid. They derived salicylic acid from pain creams which they relate to oil of wintergreen (methyl salicylate) and a link to potentially natural sources of reactants. The researchers have also employed alternate catalysts such as fruit juices to synthesize acetylsalicylic acid. However, maximum reaction yields were about 55%. Industrial processes have existed for decades and have been optimized since then with reactions producing yields in excess of 90%. For an alternate process to be viable and accepted by the industry, comparable yields are imperative.

Biocatalysts have been increasingly promoted to facilitate various chemical reactions. Alternate acetylation routes using biocatalysts are possible but yields remain unattractive to

replace industrial performance. Tsuchiyama, Sakamoto, Shuichi, Haruhiko, & Kawasaki have esterified ferulic acid with glycerol using the FAE-PL enzyme, which is very similar to esterase. They found that 1% ferulic acid in the presence of 85% glycerol and 5% dimethyl sulfoxide converted 81% of ferulic acid to 1-glyceryl ferulate. Their results were confirmed through H-NMR. Mirzarakhmetova has attempted to create an esterification reaction through the use of acetylesterase, a specific form of esterase. Carboxylic acid was esterified using esterase to catalyze the reaction and acetic acid contributing to the acetyl group. Specificity of the acetyl esterase enzyme by using different reactants such as decanoic acid, hexanoic acid, pentanoic acid, and butyric acid was compared. However, once again the research showed poor yields.

Hypothesis: Acetic anhydride can be replaced with alternative acetylations sources in the synthesis of acetylsalicylic acid without negatively affecting purity, yields, and cost through the use of biocatalysts because they catalyze specific reactions.

3. Methodology:

In order to replace acetic anhydride in the reaction, the first step was to learn the conventional procedure for the synthesis of acetylsalicylic acid. After repeating this reaction multiple times to reduce the probability of human error, such as transfer errors or cross-contamination, reactions that replace acetic anhydride with alternate acetylation sources were performed. Then, the conventional catalysts were replaced with immobilized lipase and esterase and the reactions with alternate acetylation sources were performed and analyzed with respect to the yields and purity levels. For the reaction(s) that indicate comparable yields and

purity, a cost analysis was performed to compare with the conventional method of the synthesis of acetylsalicylic acid. An overall assessment that factors in yields, purity, cost, and ease of reaction was presented.

An apparent method to replace acetic anhydride in the reaction of acetylsalicylic acid was to simply replace the reagent with acetic acid. However, this reaction was excruciatingly slow and hydrolyzed back to the reagents (El-Magbri 2016). To combat this, acetic anhydride is conventionally used. The current study attempted to replace acetic anhydride with isopropyl acetate or ethyl acetate as the acetyl group contributors. One added benefit that these reactants offer is that they can be derived through bio-based sources and therefore offer a more environmentally sustainable reaction scheme.

Immobilized lipase has been recorded in certain esterification reactions and appeared a strong candidate as a replacement to phosphoric acid and sulfuric acid, which are conventionally used as catalysts to synthesize acetylsalicylic acid (Hilal 2006). Immobilized lipase is a commonly used enzyme in the field of biochemistry primarily for the use of biofuels (Desikan, Kannan, Narayanan, Kumar and Kalaichelvan 2013). Esterase was a potential candidate because of its low cost and sustainability. Esterase is ordinarily derived from porcine liver and is defined as a hydrolytic enzyme that splits an ester into an alcohol and an acid. Based on the mechanism of the reaction of acetylsalicylic acid, esterase could split the acetyl group from a different reagent such as isopropyl acetate or ethyl acetate. Furthermore, esterase remained a good candidate because it does not require cofactors (Godinho 2011).

To test reactions with the two biocatalysts in a controlled manner, certain variables such as the temperature, time on the heating plate, humidity of the room amongst others, were

controlled. Once successful, the conditions were optimized to improve yield and reduce costs. Characterization of reactions was performed using standard test methods that include NMR spectroscopy, IR spectroscopy, and melting point tests.

A cost analysis was performed to compare the cost of the substitute method with the industrial process. Detailed cost analysis data regarding the synthesis of Aspirin™ is available. Data on cost, purity, and availability of the novel reagents or processes were collected through manufacturers of the chemicals for more realistic and practical analysis.

4. Data Collection, Results, and Discussion

4.1 Baselining Conventional Method

Because an esterification reaction using a biocatalyst had not been performed in previous literature, different iterations of reactions with varying conditions were performed in order to produce the correct product. Synthesis of acetylsalicylic acid was first conducted with the conventional method as a baseline for the characterization and purity of products from altered processes of synthesis. The conventional method of synthesizing acetylsalicylic acid requires the following procedure: transfer 1 gram of salicylic acid, 10 milliliters of acetic anhydride, and 5 drops of phosphoric or sulfuric acid to an Erlenmeyer flask. Then, clamp the flask in tap water and place over a heating pot. After this, heat the water until boiling and leave the flask in the boiling water for 10 minutes. Next, add 2 mL of distilled water to the flask. After 1 minute, remove the warm water from the exterior of the Erlenmeyer flask and place the flask in an ice bath. The cold water on the exterior should enable crystallization. Once crystallization has occurred, filter product through a Büchner funnel. After this, characterization of the product was

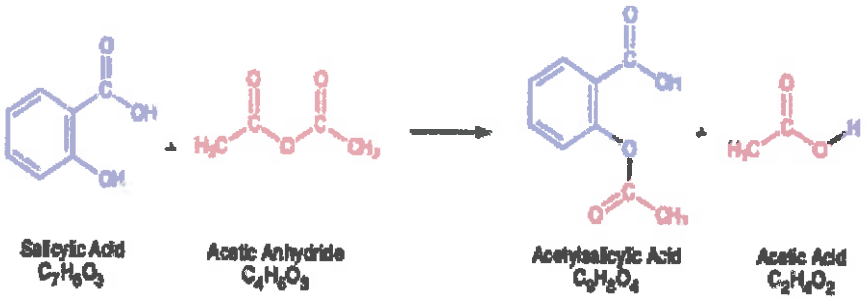
performed through NMR Spectroscopy and Infrared Spectroscopy. Percent yields were then calculated and averaged and purity was determined through melting point analysis.

4.2 Purification of Acetylsalicylic Acid:

Although there are various purification procedures, the following procedure was found to produce results of the highest purity. Dissolve crystals in 10 mL of 95% ethanol, then use a warm water bath to warm ethanol until crystals have dissolved. Next, cover the flask with a watch glass and allow the solution to cool to room temperature. Filter crystals using a büchner funnel and then wash the crystals with cold water.

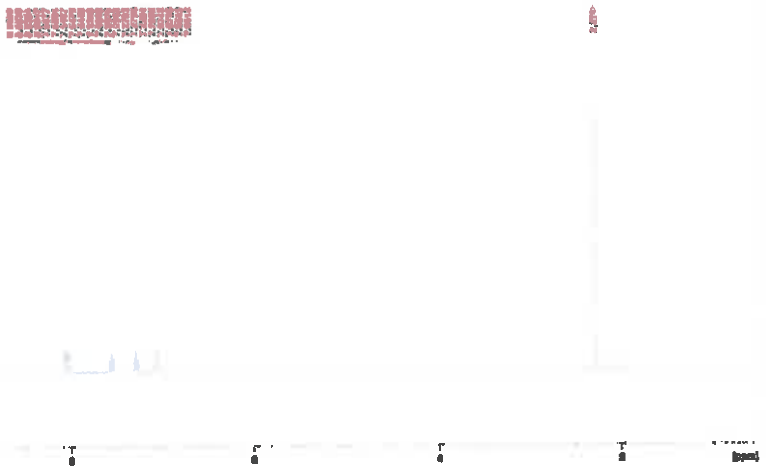
4.3 Characterization of Baseline Samples

Figure 1: Schematic of Conventional Method



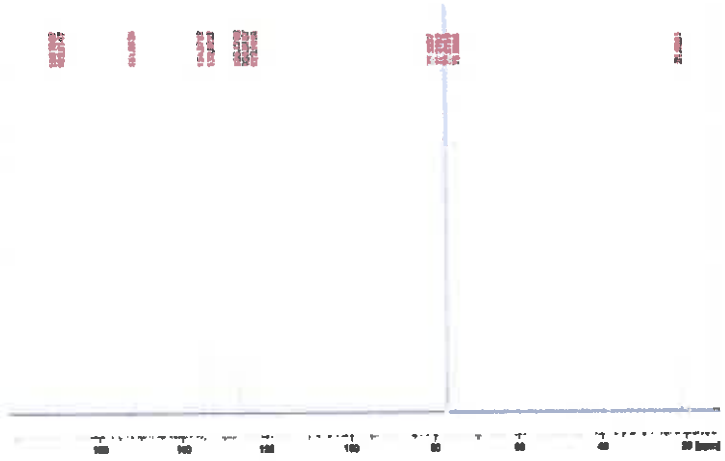
The mechanism of this reaction involves the acetylation of the phenolic group of the salicylic acid preferentially compared to the hydroxyl group in the carboxylic acid part. This is because charge density is distributed among the two oxygens of the carboxylic group causing lower nucleophilicity. Details of these mechanisms are well documented (El-Magbri 2016).

Figure 2: Proton NMR Spectroscopy of Acetylsalicylic Acid Synthesized with Commercial Method (acetic anhydride, salicylic acid, and phosphoric acid)



In the baseline NMR Spectrum of acetylsalicylic acid, multiple peaks were expected at different chemical shifts. Multiple peaks between 7.05 - 8.1 are consistent with the protons from the aromatic ring and prove the accuracy of the characterization. The most important one, though, is the methyl group (O=CCH3) which appears in an uncoupled signal at 2.27 with an intensity of 3, proving the acetylation of salicylic acid.

Figure 3: C-13 NMR Spectroscopy of Acetylsalicylic Acid Synthesized with Commercial Method (acetic anhydride, salicylic acid, and phosphoric acid)



The C 13-NMR spectra were compared with available records (Crews et al. 2009). The peaks for both the C=O Carbons at 169.7 and the methyl Carbon at 21.03 prove the acetylation and the structure of the compounds to be consistent with acetylsalicylic acid.

Figure 4: Infrared Spectroscopy of Acetylsalicylic Acid Synthesized with Commercial Method (acetic anhydride, salicylic acid, and phosphoric acid)

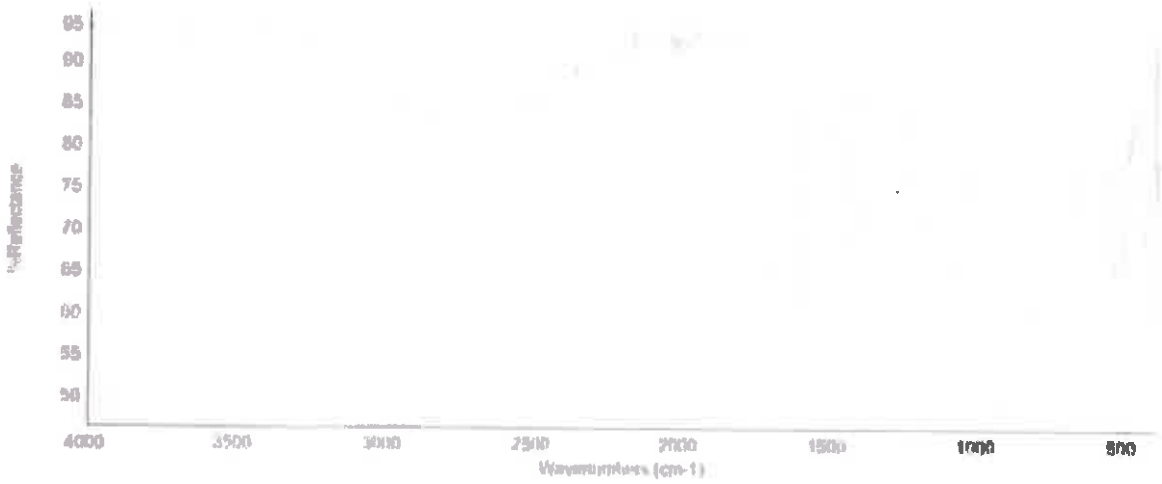


Figure 4 shows the % reflectance from IR testing in the range of around 4000-1400 cm^{-1} that identifies functional groups within the compound that was tested. 1754 cm^{-1} corresponds to C=O conjugate ester, 1693 to C=O to conjugate acid, 1483 and 1606 to the C=C aromatic, and the 1372 and 1469 peaks to the CH_3 bend, amongst others. These are all consistent with the peaks observed here, once again proving conclusively the synthesis of acetylsalicylic acid.

Figure 5: Percent Yield Calculation and Melting Point Analysis with Phosphoric Acid as Catalyst

Catalyst	% Yield	Melting Point Range (℃)
Phosphoric acid	95.2	134.7-136.2

The melting point data displayed in Figure 5 are representative of the mean values of multiple trials. Data from repeated trials were consistently within the range of ± 5% yield and melting points were within ± 2.6 °C. NIH's PubChem database reports the melting point of acetylsalicylic acid as 135 °C, which is very close to the results from the current study. This indicates a high level of purity in the sample.

4.4 Alternate Acetylation Sources

An apparent method to replace acetic anhydride in the reaction of acetylsalicylic acid is to replace the reagent with acetic acid. However, as described earlier, this reaction is slow and tends to hydrolyze back to the reagents (El-Magbri 2016). The next relevant acetylation sources are esters such as ethyl acetate and isopropyl acetate. One added benefit that these reactants offer is that they can be derived through bio-based sources and therefore offer a reaction scheme that could be more environmentally sustainable. Reactions using these instead of acetic anhydride were also very slow and had poor yields, regardless of the choice of catalysts, reaction temperatures, stirrer intensities, and reaction times. This is probably linked to the inability of the acidic catalysts to break the bulkier groups in the esters.

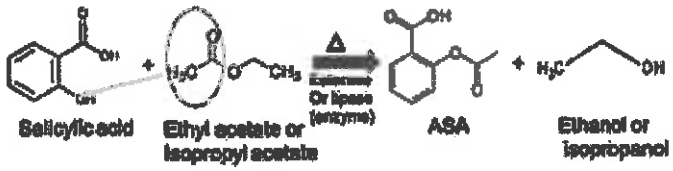
As per literature on commercial biocatalysts, compared to chemical catalysts, enzymes offer higher reaction rates, milder reaction conditions, and high reaction specificity with no side products ("Immobilized" 2016). This change enables new, more sustainable routes for the efficient and highly attractive synthetic processes on an industrial scale, with use of enzymes in catalysis being well-established technology within the chemical industry. An advantage of enzymes in organic synthesis is their remarkable selective properties, which can potentially provide commercial benefits (cost reduction) via high selectivity and easier product separation. Research for commercially available biocatalysts that had proven credentials in other similar chemistries resulted in two prominent options, which were both evaluated in the present study. Immobilized lipase has been recorded in certain esterification reactions and appeared to be a strong candidate as a replacement to phosphoric acid and sulfuric acid, which are conventionally used as catalysts to synthesize acetic anhydride (Hilal 2006). Immobilized lipase is a commonly used enzyme in the field of biochemistry primarily for the use of biofuels (Desikan, Kannan,

Narayanan, Kumar and Kalaichelvan 2013). Lipase is an enzyme that hydrolyzes triglycerides, as well as a variety of molecules containing ester linkages. Novozyme produces it on a commercial scale. In particular, Novozyme® 435, a lipase immobilized on a hydrophobic carrier (acrylic resin), has been shown to work in the following reaction, creating confidence as a trial candidate for acetylsalicylic acid (Schoenherr et al. 2010).

To test reactions with the two biocatalysts in a controlled manner, certain variables such as the temperature, time on the heating plate, humidity of the room amongst others, were reinvestigated. Additionally, because enzymes act differently than chemicals, the process for the synthesis was altered one variable at a time to first identify conditions that didn't degrade the activity of the enzymes. Temperatures up to 50 °C were determined to be safe in experiments and were also confirmed by the suppliers. Because there is very limited data on esterification reactions using a biocatalyst, different iterations of reactions with varying conditions were performed in order to produce the correct product. The first step, though, was to design the appropriate sequencing that would give the desired reaction. Three processes were evaluated before picking on the one that had the highest promise. The first one was the simplest, a one-pot solution, where the acid, ester, and biocatalyst were all mixed together and a protocol similar to the incumbent method was followed with the exception of reaction temperature, which was varied between 30 - 40 °C in the initial scoping experiments. A second process involved adding the biocatalyst in salicylic acid, stirring for 2-3 hours and then adding the solution to the ester under reaction conditions of the earlier process. Both of these processes were unable to provide desired results as checked through spectroscopy shown later. So, a new process was developed that included mixing 0.1 g of esterase with 5 ml ethyl acetate and solubilizing 1g salicylic acid in different kinds of polar and apolar solvents separately. Then reactions at about 40 °C were performed through mixing into an orbital shaker. Removal of the solvent through the evaporator to collect the product visually showed the presence of granules that were further characterized as earlier. The PNMR traces from the first two processes did not show any peak associated with the methyl group from the ester. However, the third process was shown to effectively cleave off the ester and acetylate the salicylic acid and showed an expected peak at 2.28 ppm. Melting points were also comparable to the incumbent, indicating successful conversion to acetylsalicylic acid.

For all further optimization runs, this became the base procedure to be followed. Figure 6 shows the chemistry using the two esters as acetylation sources.

Figure 6: Modified reaction scheme to synthesize acetylsalicylic acid using ethyl acetate or isopropyl acetate



The same washing and purification procedures as earlier described were used. While the key acetylation agents tried were ethyl acetate and isopropyl acetate, attempts were also made to use the same reagents made from bio sources. Bio-sourced ethyl acetate was procured from Vertec Biosolvents, whereas bio isopropyl acetate from Green Biologics. The routes used by the latter two companies to make bio sources esters is shown in figure 7, along with the results of melting point, yield and the number of washes required to achieve the listed purity. Spectroscopic traces were confirmed as earlier and have not been included here.

Figure 7: Reaction performance using alternate acetylation sources

Acetylation agent	Source	Catalyst	Yield, %	Purity (MP °C)	# Washes
Acetic anhydride	methyl acetate + CO; ketene + acetic acid	phosphoric acid	95	134.7 - 136.2	3
Ethyl acetate	ethanol + acetic acid	Esterase & Lipase	93	134.8 - 136.2	1
Isopropyl acetate	isopropanol + acetic acid	Esterase & Lipase	91	133.7 - 135.9	1
Bio ethyl acetate	bioethanol + bio acetic acid	Esterase & Lipase	91	131.4 - 134.6	2
Bio isopropyl acetate	biomass; bio isopropanol + bio acetic acid	Esterase & Lipase	90	132.6 - 134.9	2

As observed in figure 7, alternate esters from synthetic sources give acceptable yields and melting points that are comparable with those obtained via the current commercial process. The higher cleanliness of these routes is also demonstrated by the fewer washes required to yield pure acetylsalicylic acid. The esters made via the bio routes also result in comparable melting points and an acceptable number of washes. The yields of the reactions are much lower, in particular for the one using bio isopropyl acetate. This is attributed to the impurities coming along with the biomass. Also, these raw materials have recently been introduced to the world and it is expected that with time and scale, these will become purer and will consequently result in products with higher yields.

4.5 Process Engineering and Economics:

Based on the lab process devised and described above, an industrial scale process is depicted in figure 9. The changes attributed to the alternative routes are marked in green. One stream added is for catalyst recovery, to help with the higher cost of the catalyst. For this purpose, discussions with the suppliers revealed that these catalysts are available in immobilized forms with different substrates that would facilitate multiple uses of the catalysts. The process flow indicates that the overall process would be a drop-in to the existing one. Lower temperatures of reactions possible with the biocatalyst offer savings in terms of energy. Reaction times are slightly higher and have room for further optimization.

Figure 9: Industrial Scale process flow for making Aspirin. Comparison with proposed new sustainable process.

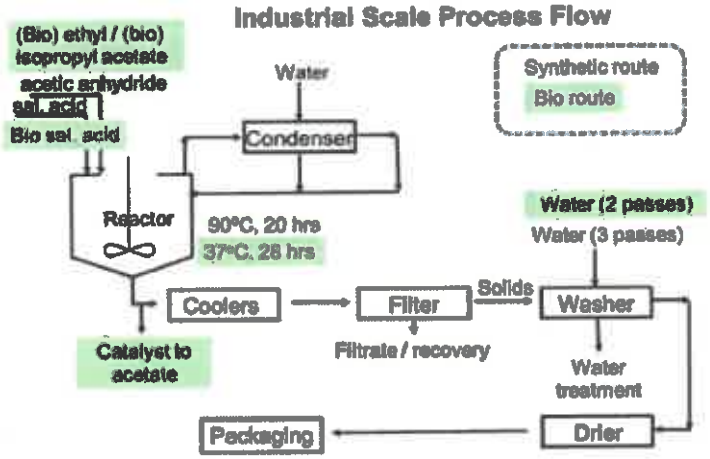


Figure 10 shows the various components of the overall costing for acetylsalicylic acid (Benaskar et al. 2011). Personnel and capital cost cover 90% of the overall cost and would remain marginally affected by moving to the new process. Energy cost is expected to decrease due to lower reaction temperatures. An analysis of the raw material cost was carried out using costs from commercial sources for medium scale plants. Raw material costs and their sources are listed in figure 11.

Figure 10: Cost components of scaled-up plant for acetylsalicylic acid (Benaskar et al. 2011)

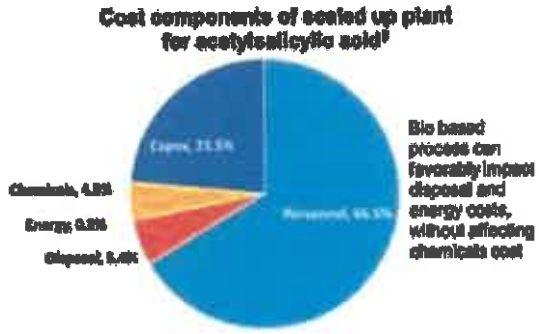


Figure 11: Raw material costs and assumptions

	MW	Cost	Unit	Source
Acetic Anhydride	102.1	1900	$/ton	orbichem.com
Salicylic acid	138.1	3	$/kg	Pharmacompass.co
Phosphoric acid	-	715	$/ton	Guizhou Qianlon In
Esterase	-	5	$/kg	LeoBio.com, pricing
Ethyl acetate	88.1	900	$/ton	sjzdwchem.en.mad
Isopropyl acetate	102.1	1400	$/ton	cie.com
Bio EA	88.1	2100	$/ton	Vertec Biosolvents,
Bio IPA	102.1	2500	$/ton	Green Biologics

One major assumption was that yields of the newer reaction schemes could be improved to approach 95% with more sophisticated optimization. This would certainly need to be validated at a larger scale through more trials, but given the closeness achieved in initial lab trials, it is not an unreasonable assumption. Using the commercial scale raw material costs, the material costs of the final product through the various routes were calculated and the results are shown in figure 12. Note that the catalyst was not included in this table as it is discussed separately later.

Figure 12: Total Material Cost of Acetylsalicylic Acid Through Different Acetylation Sources

Acetylation Source	Acetylsalicylic acid Cost, $/kg
Acetic anhydride	3.63
Ethyl acetate	2.96
Isopropyl acetate	3.34
Bio ethyl acetate	3.58
Bio isopropyl acetate	3.99

Both the esters from synthetic routes are cheaper than acetic anhydride and offer comparable yields. So, it is not surprising to see them result in lower product costs compared to the incumbent process using acetic anhydride. Ethyl acetate also provides benefits due to a lower molecular weight compared to acetic anhydride.

4.6 Cost-Effect of Biocatalyst:

The starting cost of the biocatalysts was about 5 times that of phosphoric acid / sulfuric acid. However, they have been proven to retain their effectiveness for at least 15 passes (proven for ethyl butyrate, per the supplier). They further support that the esterase is expected to show similar activity level with bio ethyl acetate and bio isopropyl acetate. This would be another factor to be validated in scaled trials. The availability of esterase in the immobilized form on agarose and silica bead substrates enables recovery and recycle. If a life term of at least 15 cycles is proven for this reaction, the overall cost of the catalysts would reduce by a factor of 3 in comparison to that of the incumbent.

4.7 Other Benefits for Manufacturers:

Besides the cost advantages coming in from the raw materials alone, there are other potential benefits for manufacturers from the process and each of these is likely to translate into benefits that were not quantified in this study. The lower level of corrosion in equipment due to the replacement of harsh catalysts (phosphoric acid and sulfuric acid) with gentler biocatalysts will prolong equipment life and decrease operating expenses due to lower maintenance cost. Cleaner profile of wastewater in a process compared to the incumbent where phosphoric and sulfuric acid streams are usually discharged into the wastewater stream, will ease water purification before it is discharged. Fewer washing steps due to high selectivity of biocatalysts equate to fewer side products and a smaller footprint (in terms of less equipment) will result in lower capital costs for new manufacturers. Finally, less exposure to harsh chemicals for operators will be beneficial from a long-term health perspective.

In summary, the new reaction schemes using alternate reactants are not expected to exceed material costs over the incumbent process. If the two major assumptions on yield improvement and life term efficiency of biocatalysts hold true, then the overall costs might even be lower for bio-based ethyl acetate due to lower energy recovery costs (lower reaction temperatures) and lower molecular weight than acetic anhydride.

4.8 Environmental Benefits:

A fully bio-based reaction scheme would reduce the CO_2 footprint associated with each ingredient and catalyst. Acetic anhydride is known to have a large CO_2 footprint associated with it. Replacing it with bio-based alternatives is a significantly positive step in helping the environment. Basing on the current global volumes of 35 kT of acetylsalicylic acid being used for Aspirin™ ("Salicylic Acid" 2016) and emission factors available for chemicals (in CO_2 eq /kg) ("Appendix" 2012), a total of about ~200,000 MT CO_2/year emission is estimated to reduce by switching to a fully bio-based process. This does not assume future growth of Aspirin(™) sales and application to other pharmaceuticals where a similar reduction could be deployed.

4.9 Benefits Toward Reduction of Opioid and Heroin Abuse:

With a viable alternative process demonstrated for manufacturing pharmaceuticals such as Aspirin ™, acetic anhydride could be potentially eliminated from the supply chain of pharmaceuticals reducing the related probability for illegal diversion into illicit heroin production. This would potentially reduce the amount of heroin proportional to the volume of acetic anhydride usage in pharmaceuticals. Assuming that this reduction scales with the number of deaths, the switch to ethyl acetate (or isopropyl acetate) could equate to about 4000 fewer deaths due to heroin overdose.

5. FUTURE WORK:

While several lab results have been shown for the first time in literature, many actions remain to be taken to advance this finding to a commercial scale. Some of the key activities for the future include:

1. Further optimization of process and scale up to larger quantities for better estimation of cost and performance.
2. Maximization of reaction yields to approach the mid to high nineties.
3. Validation of the catalyst activity as a function of number of passes under specific reaction conditions.

4. Detailed studies on residual components to support regulatory approvals for the newly proposed reactions.
5. Creation of data needed to support decisions on clinical trials.

6. CONCLUSIONS:

Synthesis of acetylsalicylic acid without using acetic anhydride was proven to work with esterase as a catalyst. A bio-sourced route, using biocatalysts with (bio) ethyl and (bio) isopropyl acetate was invented and characterized successfully. Performance attributes in terms of spectroscopic fingerprints and melting points were shown to be comparable with the incumbent process. Process economics for ethyl acetate and isopropyl acetate are favorable, with the potential to reduce cost through more optimization. A process that is economically and technically comparable to the current synthetic route, reduces CO_2 emissions by ~200 kT/year, and has the potential to reduce deaths due to opioid overdose merits further investigation to commercialize the technologies that have been proven for the first time at lab scale in literature.

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Knowledge and Perceptions of Organic Foods In College Students and High School Students

Word Count: 3,961

Interdisciplinary Framework
Psychology / Cultural Anthropology

Introduction and Literature Review

A healthy diet is a significant factor in having a healthy lifestyle, but it can be greatly influenced by food packaging design. Recently, however, the rise of organically grown foods and supposed health benefits that go along with them have changed the standards of healthy eating. Consumers now look at more factors when purchasing food: food safety, nutrition attributes, value attributes, package attributes, and production process attributes (Yiridoe, Bonti-Ankomah, & Martin, 2005). The most notable of those are package attributes, which include package materials, labeling, and other information provided.

Package design has been found to have a huge impact on consumer choices regarding food and nutrition (Kiesel, McCluskey, & Villas-Boas, 2011). Claims that are made on food labels can cause consumers to perceive food as healthier than conventionally produced counterparts. Some of these claims include: natural, all natural, organic, 100% organic, free range, and cage free. Likewise, it has been found that color also has an impact on consumer choice when purchasing products (Koenigstorfer, Groeppel-Klein, & Kamm, 2014). Overall, food labels and advertising decisions that many food manufacturers make heavily impact the likelihood that consumers will purchase particular products.

Because of the evident effect that food labeling has on consumer choices, and in turn, nutrition, many see modifying food label policy as a possible method to reduce the scale of the obesity epidemic in the United States. In the article titled "Front-of-Package Nutritional Labels and Consumer Beverage Perceptions," Kim, House, Rampersaud and Gao found that labels on beverages have a huge impact on whether or not consumers purchase those beverages, and they claim that their research, which calls for the examination and potential modification of food

labels, could reverse the rapid increase of obesity rates (2012). However, the modification of food labels to decrease obesity rates can only happen when there is an increase in the general knowledge about how food labeling affects those rates (Lenahan, Thomas, Taylor, Call, and Padberg, 1973). Since the publication of the article by Lenahan et al., however, there has been a general increase in the body of knowledge.

In addition, strategies like the one Kim et al. discussed have been proven to have a positive effect on slowing the progression of obesity (2012). In 2007, Amandine Garde looked at the European Union's strategy to prevent obesity; Garde found that the basis of their strategy was to identify where food labeling has a negative effect on consumer nutrition, and modify those labels. This strategy did have a positive effect, and aided in slowing the progression of the obesity epidemic (Garde, 2007).

These studies have shown the substantive effect that food labeling has on nutrition and health (because it influences consumer choice), as well as how it impacts consumer perception of food. However, this research will investigate factors of food labels, symbols and claims that may appear on a label, and their effect on consumer choice. It will also investigate the knowledge consumers have regarding the information that appears on food labels and, consequently, how that information influences purchase decisions and nutrition as a whole.

Much of the existing research done on this topic focuses on adults, and looks into factors that impact their purchase choices. For example, the article by Yiridoe et al. focuses on the knowledge that consumers possess regarding organic food, which is often very little, yet advertisements and claims make organic food much more appealing than conventionally produced food (2005).

Another study, by Sarah Katirji, from Kent State University, focuses on college students and their consumer choices with respect to their knowledge about food label claims. This survey aimed to assess respondents' knowledge about health food claims, and then collect some information about their nutrition. She concluded that generally college students "perceive organic as healthier and safer than conventional foods," (Katirji, 2017). Advertisements likely impacted some of the views that the students had on organically produced food.

However, similar to how quickly organically produced foods rose in popularity, advertisements and food labels change rapidly over time as well. The article "The Changing Face of Food Retailing" by Ben Senauer and Jon Seltzer places an emphasis on this, claiming that these changes arise when technology changes; both advertising technology and food production technology. These changes in technology influence expectations of food quality, and in turn, advertisements, and consequently consumer choices, change (2010). The impact of these changes are evident in several of the studies on the relationships between food labels and nutrition.

Given the fact that advertisements are always rapidly changing, and because the majority of existing research relating to this topic focuses on adults, their perception of advertisements, and consumer choices, there clearly is a gap between what is known about adults and what is known about adolescents in terms of their understanding about food labels, nutrition, and healthy eating. This research aims to identify those gaps, and begin to fill them, by comparing existing results to the results of this study. Using Katirji's existing data from her 2017 study, the gap in knowledge between the two age groups may become evident.

These groups are significant when looking at advertising and consumer choices because adults provide for their families, and if parents do not encourage healthy diets, their children will

have an increased risk of becoming obese in the future. It has also been found that poor diets cause more than three hundred thousand deaths a year, and that 35% of cancer deaths are because of poor diet. There are many links found between perception of labels and behavior/consumer choices (Nayga, 2000). This is supported by the article "Consumers' Use of Nutritional Labels While Food Shopping and At Home," by Nayga et al (1998), which found that labels heavily influence food consumption at home, regardless of gender, socioeconomic status, and other variables. Their findings also showed that education has a positive impact on the likelihood of using labels; which means that once a group is educated on the benefits on nutrition that food labels help to provide, there is an increased use of those labels (Nayga et al., 1998).

Further research done by Nayga indicates that while nearly every consumer looks at food labels, and that food labels have a huge impact on consumer choice, "[I]t appears possible that even when consumers do read labels, they do not always understand them," (Nayga, 2001-2002). This conclusion appears to be true in several other studies mentioned: the study done in 1973 by Lenahan et al., Yiridoe et al. (2005), and Katirji's study on college students (2017). Lenahan et al. introduced the need for increased knowledge in 1973, and it has been consistently found that there is still a gap in knowledge, even now. These gaps in knowledge have also been found in studies that target populations of all different ages, 18 and up. This research will identify if this lack of knowledge also exists in consumers who are younger than 18, and where these gaps in knowledge should be filled, potentially at school.

Methods

The goal of this research is to investigate high school age students' knowledge, perception, and purchase patterns of organic food and compare that to the knowledge and perception of college aged students. While a meta-analysis was considered for conducting this research, there were not enough existing studies on this topic to create valid conclusions. Additionally, no data were found on purchasing/consumption trends among high school age students, making it impossible to answer my research question using that method. A survey was chosen as the best method because it can be sent out to more people from various areas, rather than one city, which will increase the amount of responses that will be received, and consequently, improve the validity of the data collected. It was also the most commonly used method in studies relating to this topic. A survey will also allow for all questions to fit the focus and meet the goals of this research.

In order to completely answer the research question, the results of this survey will also be compared with the results from Sarah Katirji's research on this topic. Katirji's study was chosen because of the similarity to this research and its goals. Her research investigated the relationship between knowledge and perceptions of organic foods and purchase patterns. This source will be used because her research focused on adults, and comparing it to this research (in which the targeted population are high school age students) will enable investigating and comparing the gaps in knowledge of those two groups.

The survey used in this study was adapted from the survey that Katirji used in her study in order to collect results that can be most accurately compared to hers. It was modified to better fit the targeted population, high school students, with wording slightly changed (although similar enough for results to be compared). The overall structure remained the same, with four sections:

Purchasing/Consumption, Knowledge, Perception, and Demographics. A consent form and follow up statement were also included.

The first section, purchasing/consumption, looks at respondents' purchasing and consumption trends. While Katirji's survey looked at only purchasing trends, this survey targets a younger population so consumption will be investigated as well, due to the fact the majority of high school age students are not their families' primary food buyer. This section of the survey asks if respondents (or their families) purchased/consumed organic foods, and how frequently they did. For this section, the answer choices are regularly, meaning at least once a week, often, meaning three times a month, sometimes, at least once a month, and rarely, at least once every six months. The answer choices 'I purchase and/or consume non-organic versions of this food,' 'I never purchase/consume this kind of food,' and 'Not sure' were also added to decrease the amount of omitted answers, increasing the validity of the results. This section aims to provide a baseline for comparison to the knowledge and perception sections (as I am looking at purchasing/consumption trends and its relation to knowledge and perception).

The second section is the knowledge section. This section aims to assess participants' knowledge of organic food production. This section was kept the same as Katirji's because this research aims to identify if there is a gap/difference in knowledge of organic food between these two groups, adults and high school students, so the section needs to be identical to enable meaningful comparisons of scores. The section contains ten multiple choice questions that assess the level of understanding the respondent has on the following topics: organic food and agricultural practices, food labelling and certification of organic food, and organic food

regulations. It is scored with a correct answer scoring one point, and an incorrect answer scoring zero points out of a possible ten total points.

The third section aims to compare participants' perception of organically produced food to conventionally produced food. It contains several statements for which participants provide their opinions on the validity of the statements by selecting an answer choice from the following list: strongly agree, agree, neutral, disagree, and strongly disagree. This section reveals how participants generally feel about organic food, which can be compared to their responses from other sections. This section is the longest, with 29 questions. This increases the validity of the section, allowing for better conclusions to be made. The statements assess participants' ideas on the cost, preferences, availability, quality, and trust in health claims of organically produced food.

Lastly, a demographics section is included to investigate other trends in data, that Katirji also looked at; specifically, gender identity and purchase patterns. It will also ensure that my results represent the intended population (by verifying the age of the participants). A question is also included, asking if the participants consider themselves to be environmentalists.

After approval from IRB, the survey was distributed via email, and the link was shared on social media. Trusted faculty members accessed student emails via the system, and sent it out to students. The transmittal email contained the link to the consent form and survey. The email also informed recipients that their responses would remain anonymous and timestamps, I.P. addresses, and names would not be collected.

Data were exported from SurveyMonkey into Google Sheets for analysis. The statistical significance threshold was set at 0.05. Demographic data were analyzed with descriptive

statistics. Perceptions of organic food and conventional foods were analyzed using t-tests, and the correlation between perceptions of food systems and knowledge scores were analyzed with a correlational analysis and an r value; a t-test was also done to determine significance.

Results

Over one hundred and fifty students participated in the survey. Some results were excluded due to the participant not meeting the requirement that they be in high school, and age 13-18, or not completing the entire survey. Because the aim of this research is to compare survey responses between adults and high school age students, all results gathered from this study will be presented similarly to, and placed beside those from Katirji's study in order to accurately compare the two.

Table 1 shows statistics from the demographics section of the respective surveys. Both Katirji's study and this study had more participants that identified as females. In this study's survey, 82.34% of participants identified themselves as female; whereas, 17.54% of participants identified as male. In both studies, most of the participants were Caucasian; over 70% in both studies. Additionally, both in Katirji's study and this one, most participants responded yes to the question asking if they considered themselves environmentalists. In this study, 68.42% of participants considered themselves environmentalists and 31.58% didn't. This demographic matches up well in order to compare the following results.

Table 2 looks at the average perceptions of organic food versus the average perceptions of conventionally produced food. High school students perceived organic foods as more humane with a p value of 0.046, which indicates that it is statistically significant. High school students

also perceived it as safer for children to consume ($p = \leq 0.001$), tasting better ($p = \leq 0.001$), and providing additional health benefits ($p = \leq 0.001$). In both studies, conventionally produced food was perceived as more affordable with a p value less than 0.001 in both instances. High school students perceived organically produced foods significantly more nutritious than conventionally produced foods ($p = \leq 0.001$); whereas, college students perceived them as more nutritious but with a p value of 0.647, which is not statistically significant.

Table 3 shows the average perceptions of organically produced food and conventionally produced food. The college students in Katirji's study on average perceived organically produced foods as better than conventionally produced foods ($p = \leq 0.001$). High school age students generally perceived organically produced foods as better than conventionally produced foods, but with a p value of .123 which is not statistically significant; however, this finding can provide some insight for future research.

Table 4 compares knowledge scores between demographics. For this particular section, only males and females were considered due to the lack of other responses in the survey. In Katirji's study, males on average scored 4.32 on the knowledge section, and the average score for females was a 4.45 ($p = 0.803$). Despite not being statistically significant, this data point can still provide insight for conclusions made in the discussion section. This study found that on average, males scored a 5.27 and the average female scored 6.11 ($p = \leq 0.001$). When looking at buyer types, the organic food buyers from Katirji's study were compared to organic food consumers in this study, and the organic food non-buyers were compared to non-organic food consumers. This was because high school students are not generally the primary food buyer in their household. It was found that the average organic food buyer (from Katirji's study) scored a 4.36 and the

average non-organic food buyer scored a 4.47 ($p = 0.381$). The average organic food consumer scored a 5.35, and the non-consumer scored a 6.11 on average ($p = \leq 0.001$).

Table 1

Demographics			
		Frequency (Katirji's Results)	Frequency (My Results)
Gender			
	Male	24.7%	17.54%
	Female	73.9%	82.46%
	Other	0.6%	0.0%
	Do not wish to specify	0.7%	0.0%
Ethnicity			
	American Indian or Alaska Native	5.0%	N/A
	Asian	4.2%	17.54%
	Black or African American	5.8%	3.51%
	Caucasian	81.2%	71.93%
	Hispanic	2.2%	0.00%
	Native Hawaiian or Other Pacific Islander	0.2%	N/A
	Other	0.4%	7.02%
	Do not wish to specify	0.2%	0.00%
Do you consider yourself an environmentalist?			
	Yes	57.30%	68.42%
	No	42.70%	31.58%

[a] $\bar{x}\pm SD$ = Mean ± Standard Deviation

Table 2

Organic Food and Conventional Food Perceptions						
	Katirji's Results			My Results		
Statements	Organic $\bar{x}\pm SD$[a]	Conventional $\bar{x}\pm SD$[a]	P value[b]	Organic $\bar{x}\pm SD$[a]	Conventional $\bar{x}\pm SD$[a]	P value[b]
Livestock systems are more humane	3.71±1.00	2.29±1.00	≤ 0.001 *	3.97±0.95	2.34±1.07	0.046 *
Safe for children to consume	4.13±0.76	3.23±0.89	≤ 0.001 *	4.28±0.64	3.53±0.75	≤ 0.001 *
Taste better	3.39±0.93	2.94±0.97	≤ 0.001 *	3.17±0.90	3.09±0.82	0.592
More affordable	2.34±0.93	3.90±0.83	≤ 0.001 *	2.36±0.89	4.09±0.84	≤ 0.001 *

Provide additional health benefits	3.62±0.96	2.50±0.83	≤ 0.001 *	3.62±0.91	2.71±0.84	≤ 0.001 *
More nutritious	3.63±0.95	2.70±1.00	0.647	3.81±0.91	2.84±0.89	≤ 0.001 *

[a] $\bar{x}$±SD = Mean ± Standard Deviation

[b] *p* values based on t-test

Note: Likert scale was scored with 5 being strongly agree, 4 being agree, 3 being neutral, 2 being disagree, and 1 being strongly disagree.

* Denotes significance $p \leq 0.05$

Table 3

Average Perceptions of Organic and Conventional Food

	Katirji's Results		My Results	
	$\bar{x}$±SD[a]	P Value[b]	$\bar{x}$±SD[a]	P Value[b]
		≤ 0.001 *		0.123
Organic Perception	3.42±0.59		3.64±1.04	
Conventional Perception	2.93±0.50		3.13±1.06	

[a] $\bar{x}$±SD = Mean ± Standard Deviation

[b] *p* values based on t-test

Note: Likert scale was scored with 5 being strongly agree, 4 being agree, 3 being neutral, 2 being disagree, and 1 being strongly disagree.

Note: Each respondent was asked their perception with respect to organic and conventional processes, the values above list the average perception score of each production method.

* Denotes significance $p \leq 0.05$

Table 4

Comparison of Organic Food Knowledge with Gender and Buyer/Consumer Type

	Katirji's Results				My Results			
	Organic Food Buyer $\bar{x}$±SD[a]	Organic Food Non-Buyer $\bar{x}$±SD[a]	$\bar{x}$ Total[b]	P Value[c]	Organic Food Consumer $\bar{x}$±SD[a]	Organic Food Non-Consumer $\bar{x}$±SD[a]	$\bar{x}$ Total[b]	P Value[c]
Gender				0.803				≤ 0.001*
Male	4.23±2.22	4.39±1.99	4.32±1.99		5.22±1.30	5.50±0.71	5.27±1.19	
Female	4.40±2.15	4.50±1.76	4.45±1.98		5.36±1.58	6.11±1.83	5.50±1.64	
Buyer Type				0.381				≤ 0.001*
Organic Food Buyer/Consumer			4.36±2.16				5.35±1.51	
Non-Organic Buyer/Consumer			4.47±1.77				6.11±1.83	

Note: In Katirji's study, buyer type was categorized as an organic food buyer or non-buyer; buyers indicated that they purchased organic foods at least three times a month. In this study, organic food consumers indicated that they consume organic food at least somewhat regularly, and non-consumers do not consume organic food.

[a] $\bar{x}\pm SD$ = Mean ± Standard Deviation

[b] $\bar{x}$ Total = Mean Total

[c] p values based on a three-way factorial ANOVA

Note: Student knowledge scores ranged from 0 to 10; each incorrect answer was scored zero and each correct answer was one point.

* Denotes significance $p \leq 0.05$

Discussion

This study aimed to discover and explore differences in the level of knowledge about organic food production and perceptions of organic food and conventionally produced food that high school age students have versus college students. My research question was mostly addressed; however, specific gaps in participants' knowledge could not be identified. Most results lined up with predictions based on existing sources; however there were some surprises that will be addressed in this section.

The population for this study, similarly to Katirji's study, was made up mostly of females. This is similar to previous studies focused on the same topic. This might be due to females having the typical primary food shopper role in households (Lake et al., 2006). They also may be more likely to consume organic food than men are (Curl et al., 2013). Additionally, more than two thirds of the sample population considered themselves environmentalists. This could be due to the fact that it is more likely for someone interested in the environment to be interested in organic foods and or consume organically produced foods.

Lining up with Katirji's conclusion that generally, college students "perceive organic as healthier and safer than conventional foods," (Katirji, 2017), high school students also

(according to my results) perceived organic foods as healthier and safer than conventional foods. My findings for the perception section of this research align with the existing body of knowledge regarding this topic, even though that body of knowledge is quite small. This could be due to the presentation of food production in school settings/curriculums; organic food systems are often presented in a positive light, whereas conventional food systems are criticized or covered negatively. Despite this not explicitly being proven by my or other research, this potential tendency may hint towards the need for inspection of school curricula and unbiased lesson plans. Thompson and Kidwell's study from 1998 concluded that individuals with a science education consumed more organic food than those without; this could translate to education in general, as seen in this study's results.

The results from the knowledge part of the survey, lined up with Katirji's, but were unexpected in the context of the assumptions and predictions from the sources relating to this topic. In both Katirji's study and this study, the non-organic buyers or non-organic consumers, on average, scored higher than the organic buyers and consumers. This was surprising because it was expected that the organic buyers would know more, due to purchasing and consuming them (under the assumption that people are most likely to be more knowledgeable about the food type that they are actually consuming). Both college age students and high school age students scored relatively low on the survey, getting around 4 to 6 out of the 10 questions correct. It was also expected that college students would score higher on average on the knowledge section; however, that was not the case. This could have been because of the relatively small sample size in this study, and the limited diversity in respondent demographics; it also should be noted that in

Katirji's study, her data were not statistically significant in this section, which calls for further research.

Overall, according to the data that were collected in this study, organic food knowledge and perceptions are influenced by knowledge of organic and conventional food production. Therefore, they are impacted by the amount of completed education, age, and type of education (Katirji, 2017). Additionally, with the generally low scores on the knowledge section, a conclusion can also be made that education about food production in general needs to improve, as it is very important in keeping obesity rates low (Kim et al., 2012). If people are better educated about food production, they can better understand food labels and consequently make better purchasing/consumption choices, improving their health.

Limitations

There were several limitations to this study. The sample population was not demographically diverse, which may have skewed the data. In addition, the sample population was relatively small, and despite the statistical significance in most of my results, conclusions could easily be stronger with a larger and more diverse sample population. It was also more likely that people that had an interest in food systems, the environment, or nutrition would participate in this study, which also skews data; this has a larger impact due to the size of the sample population. Another limitation is the difficulty in comparing organic food consumption between college students and high school students; this is because high school students are even less likely to have the complete freedom to choose what they buy and eat than college age students. Furthermore, none of the survey questions were marked as required, which lead to incomplete surveys and unusable data.

There were also limitations present while comparing this study's data to Katirji's data. Raw data from Katirji's study were not available, so this study only used data that were presented in her paper. This meant that only means and *p* values could be compared, and the data analysis for this study was somewhat limited, as the goal of this study was to compare with results from Katirji's.

Implications

The data collected indicate a higher perception of organic food in both high school and college aged students, despite a low level of knowledge of organic food production regulations and practices. The data suggest that, disregarding low knowledge scores, high school and college age students believe that organic food production methods are better for the environment and safer; this is correct, as Katirji noted in her paper: "the best benefit to consuming organic is the protection [it] provides to the environment," and that this is due to the use of environmentally sustainable agricultural practices used by organic farmers (USDA Introduction to Organic Practices, 2015).

The research shows the need for increased and improved education about food production systems, food safety, and production practices and regulations, to help consumers make informed decisions about the food they buy and eat. Education curriculums and lessons should be reviewed to ensure they are presenting information in a comprehensive, unbiased, and clear way. The availability of this education should be made equitably accessible to all, regardless of socio-demographic characteristics, to truly guarantee informed decisions by all consumers.

Conclusion

In summation, the results of this study found that high school students and college students did have different levels of knowledge about organically and conventionally produced foods. They had similar perceptions of both, however, generally perceiving organic foods as superior to conventional foods: better for the environment, having additional health benefits, more humane, more tasty, and safer for people to consume. Conventionally produced foods were perceived as more affordable. It is clear that there is a lack of knowledge of food production, safety, regulations, and agricultural practices, in people of all ages, and this could be addressed with up to date and readily available education.

Future research could examine the level of knowledge different age groups have, and or at different times in education. They could also look at if these conclusions still stand in future years (assuming little to nothing had changed regarding the teaching of this topic). Based on this study and previous studies, a survey was a good method to examine the knowledge and differences in knowledge of organic food between age groups, but it would be optimal to survey both/all age groups at the same time to ensure maximum comparison and stronger conclusions. A bigger sample size would also help the validity of the conclusions. Additional research is needed with respect to both college and high school students and organic food purchasing/consumption and perceptions and knowledge, as it is extremely important in personal nutrition, the environment, and global obesity rates.

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Financial Literacy and Background Factors Among Teenagers: An In-Depth Analysis

Word Count:

Introduction

The topic of financial literacy, defined as the ability to make informed and effective decisions regarding financial matters, has gained considerable attention in recent years, especially in the context of teens. Numerous studies have been conducted to examine the correlation between financial literacy of teenagers and various demographic factors. However, the literature on the relationship between financial literacy and teenagers' household incomes is lacking, with many questions remaining unanswered. This paper aims to contribute to the literature on financial literacy among teenagers with a main focus on household income and the correlation between the two, and investigate whether higher levels of financial literacy are associated with higher estimated household income and other background factors.

Literature Review

Financial literacy rates among youth

In this literature review, a few major works examine the concept of financial literacy within the context of students and adolescents. The U.S. Bureau of Labor Statistics has annually provided the authoritative source for the literature on this topic with their compilation of data in the "National Longitudinal Survey of Youth." In the study, respondents' sociodemographic, family, and peer characteristics have been examined in relation to financial literacy. Using this rich data set, in 2010 Annamaria Lusardi, Olivia S. Mitchell and Vilsa Curto compiled the work "Financial Literacy among the Young," which analyzed financial literacy among youth through testing and categorizing the data in accordance to average young adults' proficiency in specific fiduciary topics versus others. Throughout their analysis of the data, they came up with one key

realization: "financial literacy was severely lacking among young adults" (Lusardi, Mitchell, and Curto, 2010, pp. 374).

However, this conclusion appears to be a widely agreed upon consensus regarding financial literacy and teenagers. A 2021 work produced by Oscar Contreras, Ph.D. and Joseph Bendix from the Milken Institute titled "Financial Literacy in the United States" compiled a comprehensive and systematic overview of the U.S. financial literacy landscape by analyzing existing studies, surveys, and indicators. After mulling over expansive quantities of studies and data, Contreras and Bendix found it glaringly obvious that the young individuals of the United States "lack the basic knowledge and skills required to engage in sound financial decision making" (Contreras and Bendix, 2021, pp. 4). For instance, the OECD Programme for International Student Assessment (PISA) is a triennial survey assessing the knowledge and skills of 15-year-old students in several key areas, including a module on financial literacy designed to measure basic financial knowledge and understanding. The findings from the 2018 PISA assessment showed that on a 1,000 point scale, the national average among 15 year-olds is 506 (Contreras, Oscar, and Bendix, 2021, pp. 374).

Other studies examining financial literacy and K-12 students in different capacities generally arrive upon the same conclusion: financial literacy is low. In "A Study of High School Economic Literacy in Orange County, California," Chiara Gratton-Lavoie and Andrew Gill administered the Test of Economic Literacy (TEL) to students of seven different high schools and concluded that "for the high school students in our sample ... knowledge of economics is not strong" (Gratton-Lavoie, Chiara, and Gill, 2009, pp. 446).

In each study regarding the subject, regardless of the metrics used to measure it, indicators point to the low financial literacy rates among K-12 students. The works of Annamaria

Lusardi, Olivia S. Mitchell and Vilsa Curto employed a few specific questions to gauge proficiency in different financial topics. The empirical data suggested that the general rate of correct responses was low (Lusardi, Mitchell, and Curto, 2010, pp. 374). In Oscar Contreras and Joseph Bendix's work, they said that the low PISA scores were indicative of the United States' low financial literacy levels (Contreras and Bendix, 2021, pp. 4). Chiara Gratton-Lavoie and Andrew Gill, using the TEL scores, reported that before any formal economics education, the percentage of students that were economically literate was low (Gratton-Lavoie, Chiara, and Gill, 2009, pp. 439-440). Regardless of the indicators used to measure it, every study examined has found low rates of financial literacy among youths.

Childhood influences on financial literacy

Several studies have attempted to explain the findings of the above studies that demonstrate a low level of financial literacy among youths. Several major bodies of literature have explored why adolescents have a low level of financial literacy, namely what types of financial advice they received as children.

Paul W. Grimes, Meghan J. Millea and M. Kathleen Thomas studied the economic literacy exhibited by K-12 teachers, the most seemingly obvious sources of influence on children growing up, in "Testing the Economic Literacy of K-12 Teachers: A State-Wide Baseline Analysis." An analysis of demographics and educational backgrounds among Mississippi teachers, along with other TEL score-based data, found that elementary level teachers' TEL scores did not differ significantly from those of high school students who had completed only one semester of economics. Despite a lack of research on the extent to which K-12 teachers impact students' economic understanding, the study reveals that our nation's educators show low levels of financial literacy (Grimes, Millea, and Thomas, 2010, pp. 11-18).

To further the research regarding the causes of low youth financial literacy, Lusardi, Mitchell and Curto further surveyed over 10,000 students across the United States, taking into account extrinsic factors' effect on the students' financial literacy. Their study "Financial Literacy among the Young" revealed that race, mother's education, and peer traits play a significant role in financial literacy. In addition, the report argues that young adults should not be generalized as one group, rather grouped according to their race, sex, and educational status, advancing the idea that financial literacy differences are correlated with demographic factors (Lusardi, Mitchell, and Curto, 2010, pp. 371-372).

According to Lusardi, Mitchell, and Curto's findings, peer and familial characteristics of adolescents growing up have a substantial impact on their financial literacy. Mother's education proved to be a very large indicator, suggesting that mothers pass along their financial advice to their children.. The financial literacy of students was also heavily influenced by peer characteristics, as those with a high percentage of peers attending church, planning to go to college, or a low percentage of peers smoking scored significantly higher (Lusardi, Mitchell, and Curto, 2010, pp. 368-375).

After reviewing the literature, it is clear that there are various factors that contribute to the low levels of financial literacy among young people. K-12 teachers, who are expected to be the primary source of financial education, demonstrate low levels of economic literacy themselves. Additionally, race, mother's education, and peer characteristics have all been found to have significant impacts on the financial literacy of young people. To address this issue, it is crucial to develop effective financial education programs that are tailored to the needs of different demographics. By providing young people with the knowledge and skills they need to make informed financial decisions, they can build a solid foundation for their financial futures.

Financial literacy and socioeconomic standing

Understanding the factors that influence financial literacy is crucial in promoting financial wellness and stability among individuals, particularly in today's economic climate. While studies have explored the impact of demographic factors such as race, sex, and education on financial literacy, the correlation between financial literacy and socioeconomic status remains understudied. Contreras and Bendix's study attempted to shed light on this relationship, but surprisingly, they did not directly compare financial literacy levels with household income (Contreras, Oscar, and Bendix, 2021, pp. 4). Similarly, Lusardi, Mitchell, and Curto suggested that financial literacy is linked to household finances and sociodemographic characteristics, but they did not obtain household income data from their respondents (Lusardi, Mitchell, and Curto, 2010, pp. 368-375). This section will delve deeper into the sparse literature on the correlation between socioeconomic standing and financial literacy and explore the potential impact of household income on financial literacy levels.

According to the reviewed studies, financial literacy is directly affected by characteristics associated with socioeconomic standing. For example, the PISA financial literacy scores of Asian and White students in the U.S. were significantly higher than those of the U.S. average. In contrast, Hispanic and Black students scored significantly lower (Contreras, Oscar, and Bendix, 2021, pp. 19). Yet, there is no body of work that can point to a group of teenagers' household income and compare it to their financial literacy test scores.

A study by Lusardi, Mitchell, and Curto showed that financial literacy was strongly correlated with family finances and sociodemographic characteristics. Specifically they stated that a "college educated male whose parents had stocks and retirement savings was about 45 percentage points more likely to know about risk diversification than a female with less than a

high school education whose parents were not wealthy" (Lusardi, Mitchell, and Curto, 2010, pp. 358). However, according to "PISA 2018 Results (Volume IV): Are Students Smart about Money?" socioeconomic background only accounts for 14 percent of the variation in financial literacy performance, suggesting that other factors are at play (OECD, 2018, pp. 97).

Although there have been several surveys and tests that have been conducted among wide bodies of students, such as National Longitudinal Survey of Youth fielded in 2008 and the 2020 Survey of the States, none of the surveys directly inquire or have any information about their household income in relation to their financial literacy levels. "Integration of a Financial Literacy Curriculum in a High School Economics Class: Implications of Varying the Input Mix from an Experiment" compiled their findings of students' experiences with fiduciary judgment, demographics, and family background, but failed to mention anything about their family household income (Gratton-Lavoie, Chiara, and Gill, 2009, pp. 437). "Financial Literacy among the Young" compiled their findings of students' familial background characteristics like college level, house ownership, religious status, and retirement plans and compared it with fiduciary judgment, but still lacked the comparison of a students' financial literacy to their household income (Lusardi, Mitchell, and Curto, 2010, pp. 362-364).

The reviewed literature suggests that there is a correlation between socioeconomic status and financial literacy, as evidenced by differences in PISA financial literacy scores among different racial and ethnic groups and parental education levels. While the works of Milken Institute, Contreras and Bendix, and Lusardi, Mitchell, and Curto suggest that household income and sociodemographic characteristics correlate with financial literacy, there is a lack of direct data linking household income with financial literacy scores. Thus, further research can be

conducted to gain more insight into the relationship between household income and financial literacy, and to identify other contributing factors.

Research Question

The purpose of this paper is to understand the various factors that influence the financial literacy of adolescents. These factors include household income, interest, experience, sources of knowledge, academic performance, and demographics. Interestingly, despite the presence of numerous studies on financial literacy for adolescents, there is no literature that focuses specifically on variable household income. The central research question that this paper seeks to answer is "what background factors are correlated to adolescents' financial literacy?"

Methodology

In order to answer the research question effectively, this paper uses a social survey/questionnaire to collect quantitative data about the relationships that form between financial literacy and various background factors. The observed studies on financial literacy among youth described in the literature review used surveys and other forms of personal inquiry. When it comes to studying how household income relates to financial literacy in young adults, a survey is an effective method. Not only does this data collection technique provide standardization across a wide sample size, but it also has other benefits such as efficient information gathering, anonymous responses, and the ability to measure various variables at once. The survey emerges as the prime choice for delving into the interplay between young adults' financial literacy and their household income.

The survey was created with two categories of questions to be answered: what is the respondent's level of financial literacy, and what is the respondent's financial background? In the first section of the survey, a financial literacy test (reproduced in Appendix A), excerpted from the study "Five steps to planning success: experimental evidence from US households," by Heinberg, Hung, Kapteyn, Lusardi, Samek, and Yoong, was administered to the respondents to gauge their financial literacy. The test score from the financial literacy tests created a proper metric to analyze and compare other characteristics with (Heinberg, et al., 2014, pp. 707). In the second section of the survey, respondents were asked 12 questions about their financial knowledge background and experience, including where they acquired their financial knowledge, what motivated them to seek the knowledge, their previous experience with finances, and their estimated household income. The financial background questionnaire for the second part of the survey is reproduced in Appendix B.

This method of gathering data provides an easy way of obtaining data from respondents at a large scale and will result in digestible, replicable data that can be used to advance the current literature surrounding financial literacy among youth. The financial literacy test questions, with 17 questions asked per participant, provides a score that can correspond to a certain level of financial literacy. By comparing the scores of respondents, the relationships between financial literacy and other factors can be identified.

The financial literacy test was developed by Heinberg, Hung, Kapteyn, Lusardi, Samek, and Yoong, who published it in their paper "Five steps to planning success: experimental evidence from US households" (Heinberg et al., 2014, pp. 707). This test is a baseline survey that includes questions related to their five concepts: compound interest, inflation, risk diversification, tax treatment of retirement savings vehicles, and employer matching for defined

contribution savings plans (Heinberg et al., 2014, pp. 707). This test allows for a binary answer to financial literacy, because if a participant scores approximately 11 out of the 17 questions correctly, they can be considered financially literate, according to Annamaria Lusardi, a professor at George Washington University, and one of the researchers who created the test.

The second portion of the survey regards the respondents' financial background including where they acquired their financial knowledge, their desire to seek out the knowledge, their prior experience dealing with finances, and their household income. This created adequate amounts of data for correlations to be drawn between all of the above factors and participants' financial literacy.

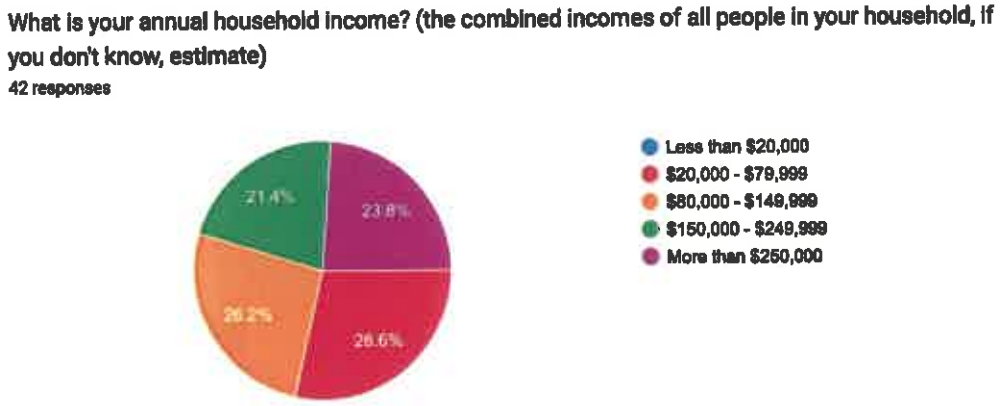
Acquiring data for the experiment was done through sharing the link to the online survey to high-school students in Evansville, Indiana. The students were not given a time limit and were required to fill out all questions for both parts of the survey. The diversity in race, socioeconomic class, and gender at the high school provided a diverse and reliable sample. Before administering the survey, the participants were informed that they should honestly select the "don't know" option if they do not know the answer, so as to not skew the data.

Results

Respondent demographics

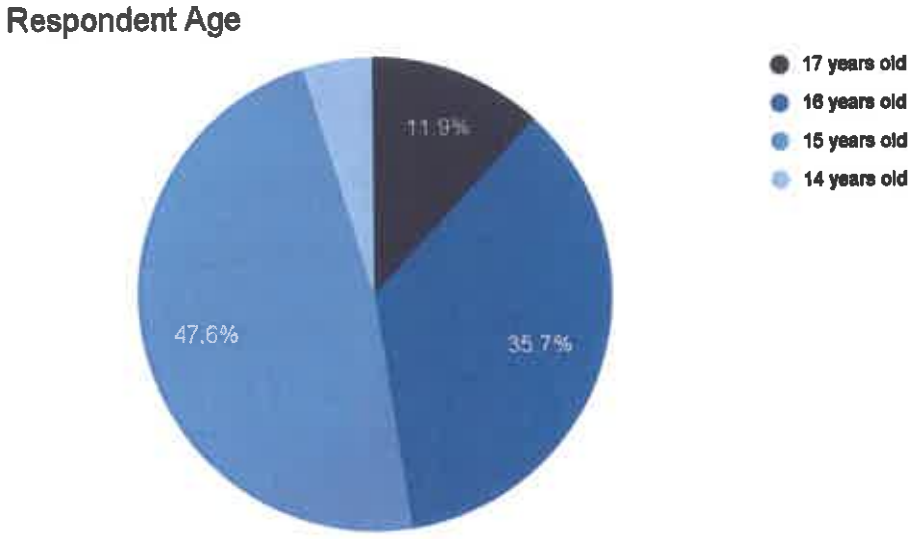
A total of 42 responses were collected for the survey, aimed at exploring the correlation between the financial literacy of teenagers and their household income and other factors. The results contained a balanced representation of participants across different household income brackets, with roughly a fourth of respondents in each income bracket, as illustrated in Chart 1, which displays the distribution of participants based on their household income.

Chart 1. Estimated Annual Household Incomes of Respondents



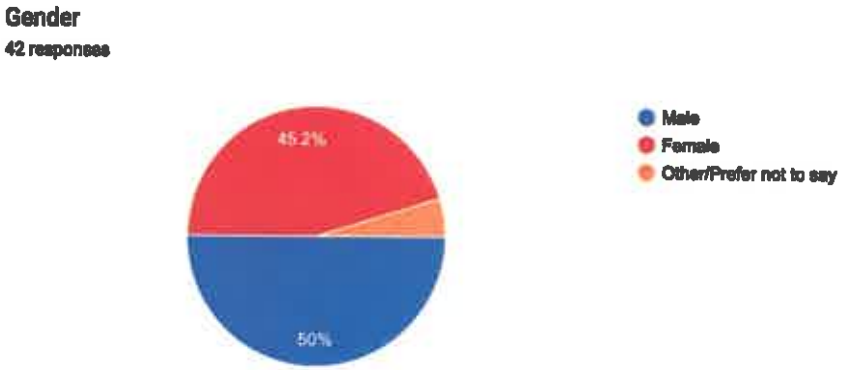
As shown in Chart 2, the majority of respondents were 15 years old. The age distribution was heavily skewed towards 15 and 16 year olds, with a lesser representation of other ages. This could pose a problem to the validity of the experiment, as a higher concentration of 15 and 16 year old respondents with a small sample of 14 and 17 year olds may skew the perceived results of mean score to age.

Chart 2. Age of Respondents



The gender distribution of the participants was fairly balanced, with half identifying as male, 45.2% identifying as female, and the rest identifying as other/prefer not to say. This information is shown in Chart 3.

Chart 3. Gender of Respondents



Survey results: Financial literacy

For the financial literacy test section of the survey, the mean score was 10.24 out of 17 points (i.e., number of questions answered correctly), and the median score was 10 out of 17 points, with a range of 3-17 points. This indicates that the majority of participants scored close to the mean, with a wide range of scores. The mean male score was 11.38, the mean female score was 9.05, and the mean 'Other/Prefer not to say' score was 9.50, as displayed in Chart 4. The p-value is 0.029, making the difference statistically significant. The discrepancy in scores between male and female was expected, as prior literature in financial literacy found similar discrepancies between the two, which favored male respondents (Contreras, Oscar, and Bendix; Gratton-Lavoie, Chiara, and Gill; Heinberg et al.).

Chart 4. Mean Financial Literacy Test Score by Selected Gender

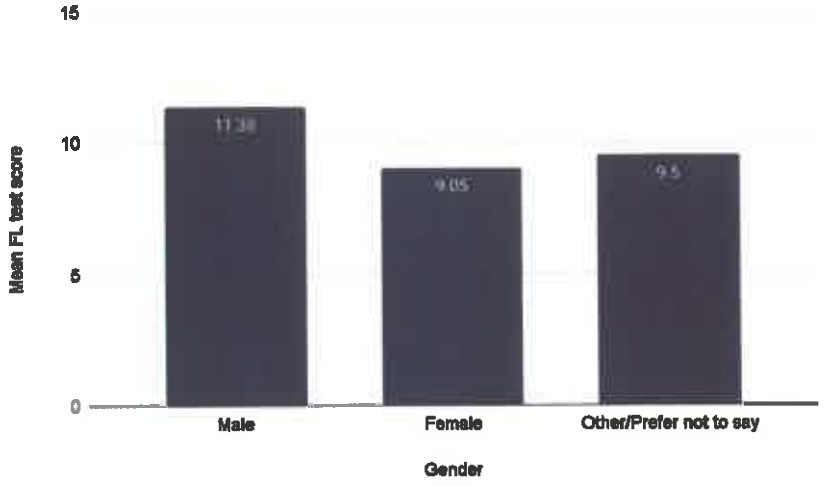
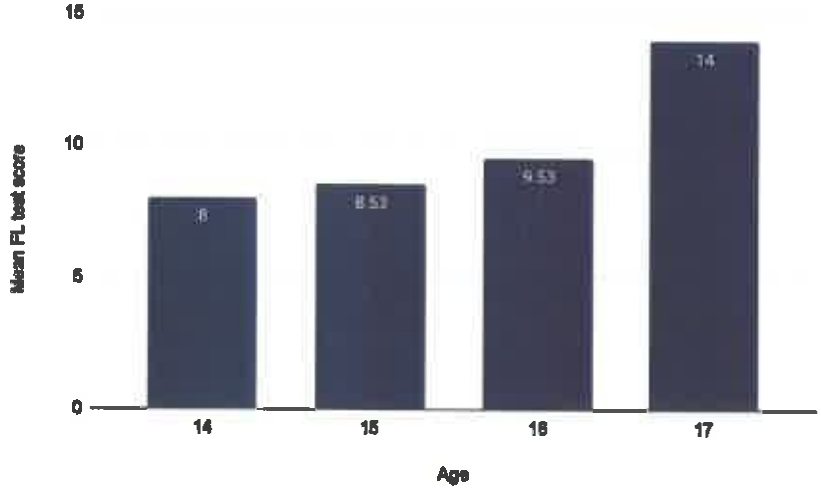


Chart 5 illustrates the financial literacy test mean scores of respondents to their age. As age increased, the corresponding mean score of the respondents increased, with a Pearson correlation coefficient (r) of 0.898 and a p-value of 0.02349, making respondents' age statistically significant.

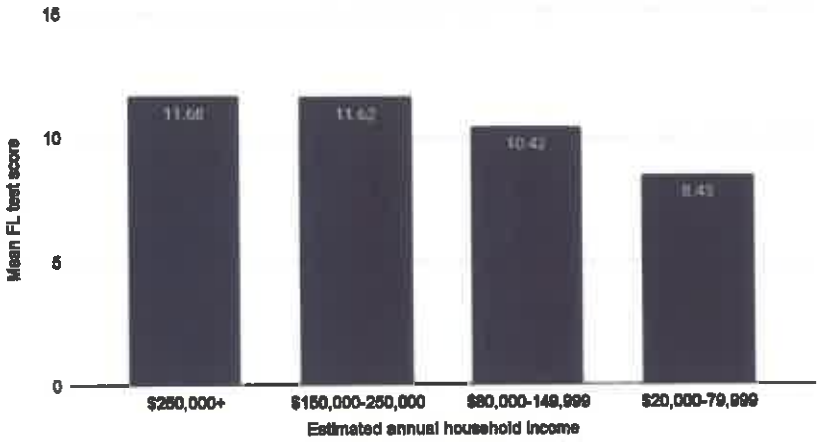
Chart 5. Mean Financial Literacy Test Scores by Age



Survey Results: Financial background

The results from the second section of the survey were used to disaggregate the financial literacy scores with financial background factors. The financial literacy test mean scores for each self-reported income bracket and displayed in Chart 6. Participants self-reporting the highest income bracket of $250k and above obtained the highest mean score of 11.68, closely followed by those in the $150k to $250k bracket with a mean score of 11.62. Meanwhile, respondents with the bracket of $80k to $150k had an average score of 10.42, and the lowest mean score was found in the $20k to $79k bracket, with a score of 8.45. The r is 0.9305, and the p-value is 0.0695. These findings suggest that individuals in higher income households may have a higher level of financial literacy than those in lower income brackets.

Chart 6. Mean Financial Literacy Scores by Self-reported Household Income Bracket



Respondents were asked to evaluate themselves on a scale of 0 to 6 of how much they agree with the provided statement, with zero being completely disagree and 6 being completely agree. The exceptions to this scale are questions (1) and (6), with (1) being from 0 as no motivation/not interested to 6 as extremely motivated/actively learns about mEstimateoney, and (6) being from 0 as none to 6 as "I know significantly more about investing than others my age." In Table 1, mean values are presented for respondents grouped by the value they chose in response to the questionnaire. Question (1), as referenced in Table 1, regarding level of motivation has an r of 0.7805, (2) has an r of 0.8665, (3) has an r of 0.2433, (4) has an r of 0.3999, (5) has an r of 0.1141, and (6) has the highest r value of 0.9616, and (7) has an r value of 0.6773.

Table 1. Mean Financial Literacy Scores by Sources of Financial Information

Respondents with self-reported ratings of:	0	1	2	3	4	5	6
(1) Level of motivation for learning about money (p=0.06699)	-	9.0	9.5	9.4	11.3	10.8	10.5
(2) Learned about money from my parents* (p=0.02554)	5.0	8.6	-	9.0	8.8	12.9	11.3
(3) Learned about money from my school teachers (p=0.599)	9.3	9.6	10.1	11.9	4.0	14.0	11.7
(4) Learned about money from my friends/peers (p=0.4322)	10.0	9.8	8.5	10.0	13.0	10.0	-

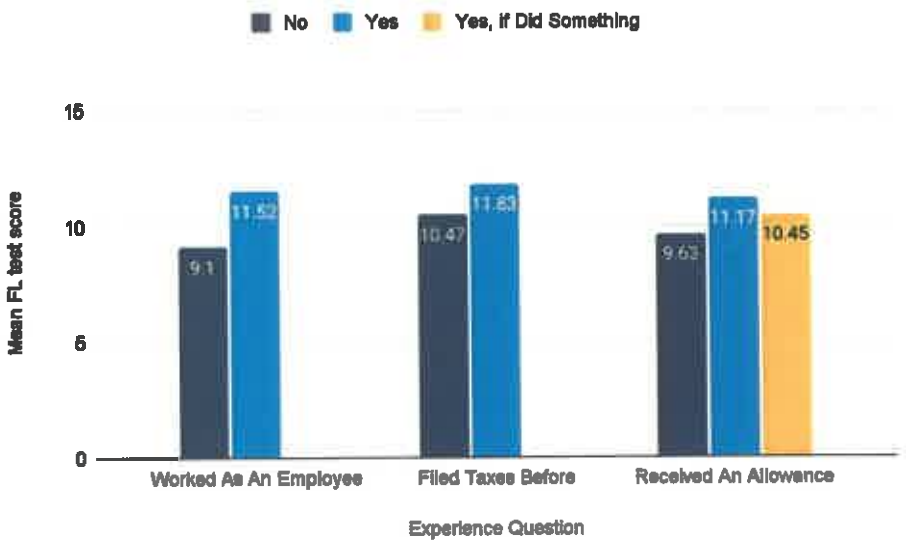
(5) Learned about money from online content (p=0.8075)	12.0	9.2	8.8	8.0	10.9	11.5	10.5
(6) Level of experience regarding investing* (p=0.0005446)	8.2	8.3	10.2	11.6	12.0	12.2	13.0
(7) Level/frequency of financial content consumption (p=0.1365)	-	10.2	9.71	9.44	10.0	14.0	12.0

*indicates that the data is statistically significant

The p-values were also calculated for each question to determine statistical significance. Based on the p-values, two of the questions are statistically significant, as the p-values are lower than 0.05, which is the widely accepted maximum value for p-values (which show the likelihood that the difference between the data is random). The questions regarding the amount of financial knowledge they received from their parents (2) and level of investing experience (6) are statistically significant.

Next, the relationship between "earning and budgeting" and financial literacy was examined. In the question asking whether or not the respondents had worked as an employee before, the mean score for those who responded "Yes" was 11.52, while those who responded "No" was 9.10. In the question asking whether the respondents had filed taxes before, the mean score for those who replied "Yes" was 11.83, while those who replied "No" had a mean score of 10.47. Additionally, the respondents were asked whether they had ever received an allowance. Those who selected "Yes" had a mean score of 11.17, those who selected "Yes, if I do/did something in return (doing chores, getting good grades, good behavior, etc.)" had a mean score of 10.45, and those who selected "No" had a mean score of 9.63. These results are displayed in Chart 7.

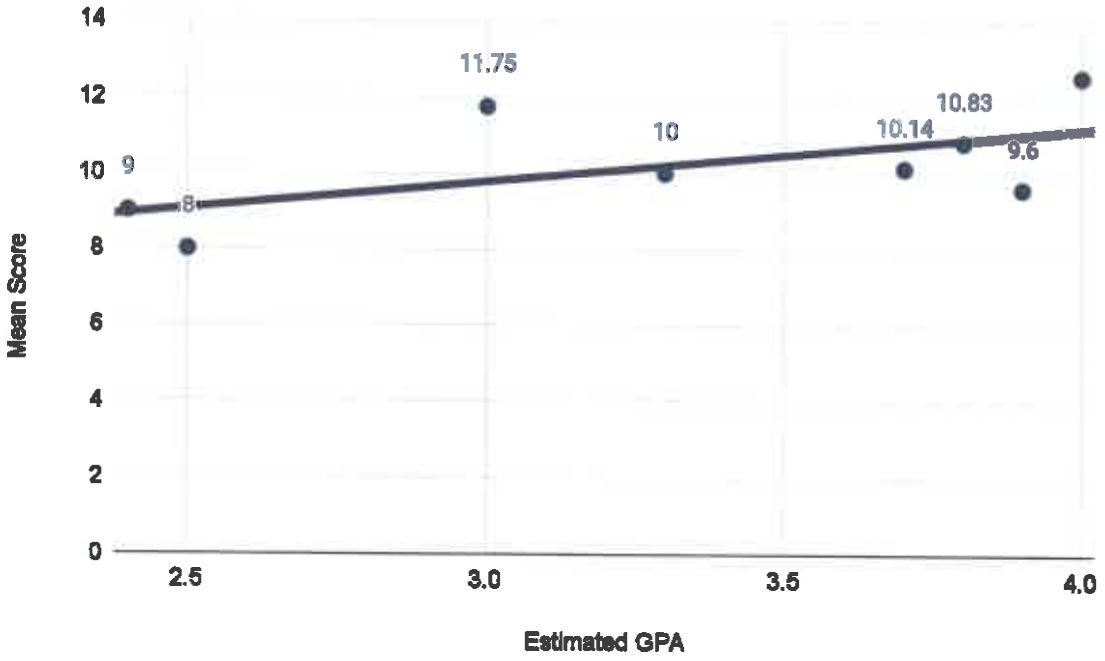
Chart 7. Mean Financial Literacy Test Scores by "Earning and Budgeting" Experience



Whether the respondents had worked as an employee seemed to play a significant role in their financial literacy test score, as those who had worked as an employee at some point scored, on average, an additional 2.42 correct questions than those who had not, with a p-value of 0.003063. Similarly, those who had filed taxes before got, on average, an additional 1.36 questions correct than those who had not, and had a p-value of 0.02893, making both variables statistically significant. Interestingly, those who did nothing to receive an allowance got an additional 0.72 questions correct than those who received an allowance with a contingency attached to it, and an additional 1.54 questions correct than those who never received an allowance, and had a p-value of 0.021, thus making allowances statistically significant.

Finally, the respondents' estimated high school grade point averages (GPA) were compared to their mean financial literacy test scores. Comparing the two, Chart 8 plots the mean financial literacy score in correlation to GPA. The r is 0.6092 and the p-value is 0.1089, meaning that the difference between the correlation of the sample is not big enough to be statistically significant.

Chart 8. Mean Financial Literacy Test Score by Estimated GPA



Discussion

The aim of this investigation was to explore the correlation between financial literacy of teenagers and their estimated household income and other financial background factors. Examining prior sources, one would assume that financial literacy has a positive correlation with household income. Although this supposition was verified, the association between the two variables was not as robust as anticipated. With the Pearson correlation coefficient (r) at 0.9305, and the p-value at 0.0695, the correlation is not statistically significant, implying that one's financial literacy cannot be predicted based on their household income. This result is surprising, given that financial literacy is purportedly influenced by characteristics associated with socioeconomic status. Since there had been no direct study attempting to explore the direct correlation between financial literacy in teenagers and household income, it was assumed in most

bodies of literature that there would be a positive correlation. Based on the results of this study, it seems that prior assumptions about the impact of household income on adolescent financial literacy, although valid, are largely overstated.

This finding seems rather contrarian, as prior literature firmly supported the significance of socioeconomic background as a predictor for financial literacy. The PISA financial literacy scores of Asian and White students in the U.S. were markedly higher than those of the U.S. average, while Hispanic and Black students obtained significantly lower scores (Contreras, Oscar, and Bendix, 2021, pp. 19). Additionally, according to Lusardi, Mitchell, and Curto, financial literacy was strongly related to family finances and sociodemographic features. Specifically, they reported that a college-educated male whose parents had investments and retirement savings was roughly 45 percentage points more likely to be knowledgeable about risk diversification than a female who had less than a high school education and whose parents were not affluent (Lusardi, Mitchell, and Curto, 2010, pp. 358).

Nevertheless, these previous studies operated under the assumption that children would absorb financial knowledge from their parents, inheriting their parents' financial aptitude or lack thereof, which may not always hold true. In contrast, this current study's findings indicate that one of the most significant factors in predicting financial literacy is the extent to which the respondents "learned about money" from their parents. The Pearson correlation coefficient (r) between the two variables (financial literacy test score and learning about money from parents) was 0.8665, and the p-value was 0.02554, attesting to the statistical significance of the correlation.

These findings show that especially in households where financial openness is lacking, financial education is important. A direct positive correlation between financial literacy and

"learn[ing] about money" from parental figures indicates that parents should strive to have an openness to talk about finances with their children. This connection also has implications for policymakers and educators, as they should aim to implement financial education in school curricula or programs, especially for those whose parents' own financial capabilities are inadequate.

Another point of interest is the relationship between adolescent financial literacy and investing experience. In response to the question "On a scale of 0 to 6, what is your level of experience regarding investing?", there was a direct positive correlation between level of investing experience and financial literacy, with a Pearson correlation coefficient (r) of 0.9616 and a p-value of 0.0005446. However, this relationship is not surprising, as a significant predictor of how well one would score on a test consisting of a few investing questions would be how experienced they are in investing.

Experience, in general, seemed to play a significant role in the true best predictor for financial literacy. Looking at the two questions asked about past employment and filing taxes, a sizable difference was able to be noticed. The respondents who had worked as an employee at some point scored 26.6% higher than their counterparts who had never been employed (11.52, while those who responded "No" had a mean score of 9.10). A similar pattern emerged for respondents who reported having filed taxes, who scored 13.0% higher than those who had not (11.83 compared to 10.47, respectively). Overall, the questions related to experience with employment and finances demonstrated the strongest correlation with financial literacy, underscoring the importance of practical experience in developing financial literacy skills.

The findings suggest that age is also a salient factor that may affect financial literacy in adolescents, with older teenagers having more opportunities to gain experience in areas such as

employment, taxes, and investments, all of which are positively correlated with financial literacy. Given the direct positive relationship between these domains and financial literacy, it stands to reason that age also exerts a significant impact on financial literacy in teenagers, as the Pearson correlation-coefficient (r) is 0.898, and a statistically significant p-value of 0.02349. However, the data set is skewed, as almost all of the respondents who are 17 years of age come from a high socioeconomic background, with higher experience in financial matters than others their age. As such, the correlation's validity may not reflect a broader teenage population and requires retesting to establish its robustness.

Finally, gender, as predicted, played a significant role in the respondents' financial literacy test score. Lusardi, Mitchell, and Curto already asserted that "many women do not do well in financial calculations and do not have a firm grasp of inflation or risk management," after noting that there was an 11-12% gap for correct response rates between males and females (Lusardi, Annamaria, et al., 2010, pp. 367). This finding has also been corroborated by Contreras, Oscar, and Bendix, who likewise saw a 10% gap between female and male financial literacy (Contreras, Oscar, and Bendix, 2021, pp. 9). Within this current study, a male respondents averaged a notable 25% higher score than their female counterparts, and a p-value of 0.029, further confirming the disparity. This difference in financial literacy between male and female respondents begs the need to open the conversation of money management and investing and address the gendered stereotypes around it. A solution to resolve this problem is for an increase in financial literacy programs tailored towards young females for engagement.

Conclusion

Overall, there appeared to be three statistically significant groups of factors that influenced adolescents' financial literacy: demographics, parenting, and experience. The two factors that fall under the category of demographics are gender (p-value = 0.029) and age (p-value = 0.02349). The two factors that fall under the category of parenting are whether respondents received an allowance or not (p-value = 0.021) and the extent to which the respondents' financial knowledge was from their parents (p-value = 0.02554). The three factors that fall under the category of experience are whether the respondent worked as an employee (p-value = 0.003063), whether the respondent had filed taxes before (p-value = 0.02893), and the respondents' investing experience (p-value = 0.0005446).

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Appendices

Appendix A. Financial Literacy Test Questions + Answer Key (Heinberg, Aileen, et al.)

1 - Suppose you put $1,000 in an account that earns 5% interest per year, every year. You never invest additional money and you never withdraw money or interest payments. So in the first year, you earn $50 in interest. In Year 4, how much will this account earn?

a. 1 Less than $50

b. 2$50

c. More than $50

d. 4 Don't know

2 - Suppose you invest $2,500 and earn 7% per year on this investment. How many years will it take for your total investment to be worth $5,000?

a. Between 0 and 5 years

b. Between 5 and 15 years

c. Between 15 and 45 years

d. More than 45 years

e. Don't know

3 - Consider the following scenario: Jack and Jill are twins. At the age of 20, Jack started contributing $20 a month to a savings account. After 20 years, at the age of 40, he stopped adding to his savings, but he left the money in the account. Jill didn't start to save until she was 40. Then, she saved $20 a month until she retired 20 years later at age 60. Suppose both Jack and Jill earned 6% interest per year on their savings. When they both retired at age 60, who had more money?

a. Jack

b. Jill

c. They had the same amount

d. Don't know

4 - Pam is deciding between 2 options: Option A: Invest $1,000 in a certificate of deposit that earns 5% interest. Pam would not add or remove any money from this investment for the next 30 years. Option B: Invest $1,000 in a savings account that earns 5% interest. Move the interest earned on this account every year into a safe at home. Pam would not add or remove any other money from the savings account or the safe for the next 30 years. At the end of 30 years, which of these options would provide the most money?

a. Option A

b. Option B

c. Pam will have the same amount of money at the end of 30 years regardless of whether she chooses Option A or Option B.

d. Don't know

5 - Suppose that by the year 2020 your income has doubled and prices of all goods have doubled too. In 2020, how much will you be able to buy with your 2020 income?

a. More than today

b. The same amount as today

c. Less than today

d. Don't know

6 - Rita must choose between two job offers. She wants to select the job with a salary that will afford her the higher standard of living for the next few years. Job A offers a 3% raise every year, while Job B will not provide a raise for the next few years. If Rita chooses Job A, she will live in City A. If Rita chooses Job B, she will live in City B. Rita finds that the price of goods and services today are about the same in both areas. Prices are expected to rise, however, by 4% in City A every year, and stay the same in City B. Based on her concerns about standard of living, what should Rita do?

a. Take Job A

b. Take Job B

c. Take either one: she will be able to afford the same future standard of living in both places

d. Don't know

7 - In general, investments that are riskier tend to provide higher returns over time than investments with less risk.

a. True

b. False

c. Don't know

8 - Which of the following is an accurate statement about investment returns?

a. Usually, investing $5,000 in shares of a single company is safer than investing $5,000 in a fund which invests in shares of many companies in multiple industries.

b. Usually, investing $5,000 in shares of a single company is less safe than investing $5,000 in a fund which invests in shares of many companies in different industries.

c. Usually, investing $5,000 in shares of a single company is equally as safe as investing $5,000 in a fund which invests in shares of many companies in different industries.

d. Don't know

9 - Suppose you are a member of a stock investment club. This year, the club has about $200,000 to invest in stocks and the members prefer not to take a lot of risk. Which of the following strategies would you recommend to your fellow members?

a. Put all of the money in one stock

b. Put all of the money in two stocks

c. Put all of the money in a stock indexed fund that tracks the behavior of 500 large firms in the United States

d. Don't know

10 - When you invest in an employer's retirement savings plan such as a 401(k), your contributions are taxed:

a. Either before you invest them or when you withdraw them during retirement, but not both times.

b. Both before you invest them and when you withdraw them during retirement.

c. Once a year on or before April 15.

d. When you reach age 65.

e. Don't know

11 - Both Irene and her employer contribute every year to her employer-sponsored 401(k) plan. Irene has worked at the company for twenty years, and is fully vested in her plan. Suppose Irene leaves her job or gets fired. Which of the following statements is true?

a. If she is no longer working for the company, the whole plan balance is forfeited, because her benefits are tied to her job.

b. If she gets fired, the company has the right to decide how much of her total plan balance she will get.

c. If she voluntarily leaves her job, she forfeits all of her employer's contributions.

d. Even if she leaves her job or gets fired, she is still entitled to the entire plan balance.

e. Don't know

12 - Which of the following statements are true?

a. In any type of IRA or 401(k) account, all of the money in your account grows tax-free.

b. If you have a traditional IRA or 401(k), you make contributions out of pre-tax income and pay income tax at your future tax rate when you withdraw the funds.

c. Both are true

d. Don't know

13 - This year, Marge's salary is $100,000 and she contributes $10,000 of her salary to a traditional 401(k) offered by her employer. Her current tax rate is 28%. In 40 years, when Marge retires, the money will have grown to $160,000. Her tax rate during retirement will fall to 20%. Which of the following is true?

a. This year, Marge should pay income taxes on her entire salary. During retirement, she will pay 20% tax on whatever she withdraws from her plan.

b. This year, Marge should pay income taxes on only $90,000. During retirement, she will pay the same deferred 28% tax rate on whatever she withdraws from her plan.

c. This year, Marge should pay income taxes on only $90,000. During retirement, she will pay 20% tax on whatever she withdraws from her plan.

d. This year, Marge should pay income taxes on only $90,000. During retirement, she will pay no tax on whatever she withdraws from her plan.

e. Don't know

14 - Which of the following is a true statement?

a. You will lose money that you personally invested in your 401(k) if you switch jobs.

b. You will be charged income tax as well as tax on dividends and increases in the value of your stock if you invest through a 401(k).

c. Unless you are undergoing significant hardship, you cannot withdraw money from a 401(k) without penalty until you reach a certain age.

d. All of the above

e. Don't know

15 - Alice wants to invest $1,000 for retirement this year. Her new employer will fully match her 401(k) contributions, up to $10,000 per year. All else being equal, which of the following options will give Alice the highest total amount at the end of the year?

a. Alice contributes $1,000 to her 401(k) plan and invests that money in mutual fund A. At the end of the year, mutual fund A has earned a 5% return.

b. Alice does not contribute to her 401(k) plan but she invests $1,000 in mutual fund B outside of her 401(k) plan. At the end of the year, mutual fund B has earned a 20% return.

c. Alice does not contribute to her 401(k) plan, but she invests $1,000 in mutual fund A outside of her 401(k) plan. At the end of the year, mutual fund A has earned a 5% return.

d. Don't know

16 - David's new job offers a 401(k). His employer provides a 50% match up to $2,000. How much should David invest at least in order to obtain the maximum amount of money from the employer match?

a. 1$0

b. $500

c. $1,000

d. $2,000

e. $4,000

f. Don't know

17 - You have decided to set aside 15% of your salary for retirement. You work at a firm where your employer matches your contribution to the 401(k) plan, dollar by dollar, up to 5% of your salary. Which of these statements is correct?

a. If you contribute up to 5% of your salary, the employer match is equivalent to a 100% return on your contribution.

b. What the employer contributes should not play any role in your decision.

c. It is always a good idea to contribute less than what the employer contributes.

d. Don't know

Answer key:

1: c 2: b 3: a 4: a 5: b 6: b 7: a 8: b 9: c 10: a 11: d 12: b 13: c 14: c 15: a 16: e 17: a

Appendix B. Financial Background Questionnaire

1. What is your annual household income? (the combined incomes of all people in your household, if you don't know, estimate)
2. What is your level of consumption of or exposure to financial/personal finance-related content/media?
3. On a scale of 0 to 6, what is your level of motivation when it comes to learning about money?
4. On a scale of 0 to 6, to what extent do you agree with the following statement:
5. "I have learned about money from my parents | My knowledge about money comes from my parents"
6. On a scale of 0 to 6, to what extent do you agree with the following statement:
7. "I have learned about money from my school teachers"
8. On a scale of 0 to 6, to what extent do you agree with the following statement:
9. "I have learned about money from my friends/peers "
10. On a scale of 0 to 6, to what extent do you agree with the following statement:
11. "I have learned about money from online content | My knowledge about money comes from online content"
12. Have you ever worked as an employee? (yes, no)

13. Have you ever had to deal with filing taxes? (yes, no)
14. Do you/did you ever receive an allowance? (yes, yes if I do something in return, no)
15. On a scale of 0 to 6, what is your level of experience regarding investing?
16. What is your estimated high school GPA? (value)