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Contents

Foreword

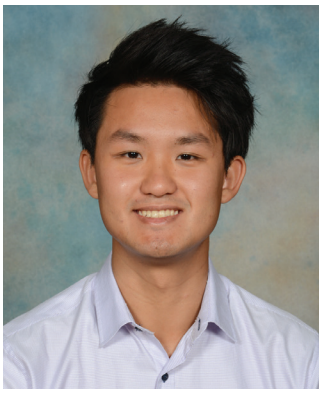
Science Extension is a new 1 Unit course studied in Year 12 only. The course is designed and structured specifically for high achieving students to extend the knowledge, understanding and skills developed in the Science courses. Science Extension also provides opportunities to engage with complex concepts and theories and to critically evaluate new ideas and discoveries through contemporary data collection and scientific research.

Brendon, Jacinta, and Jordyn are three outstanding young scientists at Cumberland High School who have accepted the exciting challenge that is Science Extension. They have worked diligently with their fantastic teacher and mentor Mr Kwan, largely outside of normal school hours to fulfil the rigorous requirements of the course.

Their excellent Scientific Research Reports are testament to their dedication and will better prepare them for university and careers in STEM. They should all be immensely proud of their achievements.

M. Walford

Mark Walford
Head Teacher Science



As the inaugural Science Extension cohort, Brendon, Jacinta, and Jordyn have paved the way for future students to also join in the scientific community as researchers, writing a journal article based on literature, primary, and secondary data. Despite the challenges faced both within the rigour of the course and current world events, these three students have shown their ability to rise to the occasion and produce three unique reports about a research question that they were passionate about. This would not have been possible without the help, support, and guidance of their family, friends, university mentors, and teachers throughout the entire process.

Regardless of what they choose to pursue in the future, Brendon, Jacinta, and Jordyn have developed the ability to apply scientific research skills to engage critically with the world. It was a privilege to be able to take this journey of genuine research with each one of these three students, and I am incredibly proud and excited to be able to share their work with you in the first issue of this journal.

Locklen Kwan
Science Extension Teacher

Student Introductions

Brendon Yue

My research report investigates the relationship between sex and the infection rate of Invasive Pneumococcal Disease [IPD]. This study was to a large extent inspired by the coronavirus pandemic. I found great interest in the transmission of diseases amongst populations, and was curious to investigate and assess the impact of human factors on the incidence of infectious diseases. Due to the new emergence of coronavirus and a limited arsenal of reliable sources, it was therefore decided to conduct research on IPD which is relatively common, well researched, and with a plethora of reliable sources.

Jacinta Zixin Chen

My research report investigates how nutrition and diet affects human health. I have always been interested in different types of healthy and unhealthy diets, and wanted to gain knowledge in food nutrition which may be helpful for a business that I am interested in pursuing for the future. I was also inspired by my friend who was conducting a low carbohydrate diet at the time. Her experience and feelings throughout her diet led me to develop my first research questions, which was later adapted to suit the datasets that I sourced.

Jordyn Chapple

I found my research topic scrolling through blogs and forums that suggested different topics for scientific research. I came across a question on the relationship between hypertension and cognitive functioning, and I found that really interesting and that there was a lack of literature on this topic. Later in my research, I had to adapt the topic, due to the lack of data and evidence. My final research paper was on the correlation of hypertension on mind wandering, and although it was not an easy process to get to the final result, I enjoyed the research in the topic.

Scientific Research Report

"Students with a passion for science explore the development of the scientific process over time by undertaking high-level authentic scientific research. Students will communicate their findings and propose further scientific research through a Scientific Research Report." (NESA 2017)

The Scientific Research Report is the culmination of a year-long research process conducted solely by the student. Throughout the year, students start off by looking at the foundations of scientific thinking, whilst also exploring some of the history of the development of science. Students then produce a research proposal, communicating their ideas and goals before commencing their research, data collection and data analysis. Throughout the rest of the year, students learn and apply skills in: analysing peer-reviewed journal articles, collecting and organising data, analysing data through graphical models and statistical tests, applying scientific concepts to their findings, and learning the formal structure of communicating their findings in the form of a report.

Students are able to pick a research topic in any field of science. This year, students have picked topics in the realm of Biology and Psychology. Brendon's project looked at the infection rate of Invasive Pneumococcal Disease amongst the Australian population. He found that there was a significant difference and suggested that further research can be done in understanding the effects of infectious diseases. Jacinta explored the effect of salt intake on the blood pressure of individuals across different age groups and sexes. Her analysis revealed that whilst there was significant difference between blood pressure of males and females, this may have been due to other lifestyle choices as opposed to salt intake. Jordyn investigated the correlation between increased blood pressure and mind wandering within a school context. Jordyn deserves commendation as there were unavoidable ethical concerns with her original plan to conduct primary research. She adapted well in switching to analysing secondary data to find there was a lack of evidence for a correlation between the two.

We hope you enjoy reading these reports that have been produced through each student's dedication and commitment, in conjunction with the continual guidance of their University of Sydney PhD mentors and their teachers at Cumberland High School.

The relationship between sex and infection rate of Invasive Pneumococcal Disease amongst the Australian population

Brendon Yue
Cumberland High School

This study investigates the relationship between sex and the infection rate of Invasive Pneumococcal Disease [IPD]. Data ranging from 2001-2019 was sourced from the National Notifiable Diseases Surveillance System [NNDSS] and manipulated to form a comparison between sex and IPD notification rates (per 100,000 individuals). This consisted of graphical representations of collated data and through a one-tailed, two sample t-test to determine whether or not there was a significant male bias in IPD notification rates. It was shown that the male sex exhibited significantly higher notification rates of IPD relative to the female sex. Reasons behind such a disparity were found to be potentially due to the impact of social stereotypes, sociability, lifestyle choices, and sex hormones.

LITERATURE REVIEW

Invasive Pneumococcal Disease [IPD] is caused by the infectious agent Streptococcus pneumoniae. It refers to when the bacterium enters a sterile site such as blood, joint fluid, pericardial fluid and cerebrospinal fluid (Randle, Ninis, and Inwald 2011). IPD occurs most commonly as pneumonia, meningitis and sepsis amongst adults and children and can be a sign of immunodeficiency and/or chronic illness. As a result, there is an estimated annual worldwide death of 1.6 million individuals (Lamb, Diggle, Robertson, Greenhalgh, and Mitchell 2011). Due to the bacterium's growing resistance to antibiotics, there has been a development of new pneumococcal vaccines. 13-valent pneumococcal conjugate vaccine [13vPCV] and 23-valent pneumococcal polysaccharide vaccine [23vPPV] are offered and recommended by the National Immunisation Program. Due to a difference of impact on immune memory, 23vPPV is more often used in adults as the immunity triggered is short lived in young children. 13vPCVs are used for those under 5 years of age due to its tendency to establish an elevated immune memory and antibody response (Jayasinghe 2019).

Infected individuals often carry Streptococcus pneumoniae bacteria in their nasopharynx. Typically after contraction, the bacteria can foster in the nasal and throat region in biofilms which allow it to colonise and reduce the responses of the human immune system. Thus the bacteria can be spread through particles of saliva or mucus such as through the actions of coughing, sneezing, or other activities that may project and spread respiratory fluids. Certain groups are among the most susceptible to the disease, including: children below the age of two, people aged above 65 years, Aboriginal and Torres Strait Islander children and adults, people with immunodeficiency, people with chronic diseases, impaired spleen function, alcoholism, and those who smoke tobacco (Australian Government Department of Health 2020). Infected individuals can be asymptomatic and therefore the disease can be unconsciously spread among densely clustered groups. Therefore, this indicates that carriers of the disease may increase transmission and infection if they exhibit higher sociability, weakened immune systems (including infants and elderly), and reside or come in contact with densely populated or unhygienic environments.

Sex has often been regarded as a factor influencing the susceptibility to certain diseases. Such examples include human immunodeficiency virus, influenza, malaria, and parasitic diseases (van Lunzen and Altfeld 2014). Maurice, Schaffner, Griffin, Halasa, and Grijalva (2016) examined the role of sex on the incidence of IPD. The study used IPD surveillance data from the Centers for Disease Control and Prevention Active Bacterial Core surveillance program (2013) in Tennessee. It was concluded that whilst rates of IPD were significantly lower after the introduction of vaccines, a higher infection rate in male subjects (compared to female subjects) among ages of 40-64 and >74 years of age still persisted. Although no definitive causation for the disparities were discovered, it was proposed that changes in sex hormone concentrations due to aging may influence an individual's susceptibility to infectious diseases. This conclusion, however, is based on limited observations on other behaviours and environmental exposures to certain

conditions which may be contributing factors to these disparities. Furthermore, the study was restricted to the Tennessee population which may not accurately represent the diverse variables of race, socio-economics, and environmental factors.

Other studies conducted demonstrate that disparities amongst sex are observed in the occurrences of most infectious diseases (van Lunzen and Altfeld 2014). Bernin and Lotter (2014) revealed that tropical infectious diseases often displayed bias towards males in terms of susceptibility and severity. An analysis on amebic liver abscess [ALA] caused by the protozoan parasite Entamoeba histolytica found that the risk of developing ALA increases during and after male puberty with a 7:1 male to female infection ratio. It was proposed that the higher incidences were due to an increase in levels of male sex hormones (testosterone). Hormone exchange studies on artificially infected rodents showed that testosterone treatment increases the development of abscesses and parasite load in female mice that were initially resistant. Furthermore, male mice with lower testosterone levels exhibited an increased resistance to ALA when compared to male mice with normal testosterone levels. This study however does not perform such treatments on human subjects, thus conclusions on its efficacy are not definitive as humans are the only known natural host for Entamoeba histolytica. Furthermore, there is no analysis on environmental and psychological factors that can impact on the contraction and severity of a disease.

Holistic observations and analysis of the gender and sex framework have been conducted to better understand to what extent it applies to the transmission and infection rates of diseases. Vlassoff (2007) examined how differences in gender roles of men and women affect risks of infection. It was discovered that infection rates of men were higher due to the influence of societal and cultural norms. For example, diseases such are malaria are much more prevalent in men as they are more likely to be exposed to certain work environments and longer work hours; the result of being driven by expectations to provide for their families. Furthermore, it was also proposed that variances between the roles of women and men led to their separate allotment to public and domestic domains and duties. The study also explores such biases in industrialised countries. It was found that in industrialised societies, women would often perform domestic labour, whilst men were prominent in the labour force (i.e. blue-collar occupations). A supplementary study concluded that men were more likely to die from acute conditions that are sudden and severe whilst women from chronic conditions and disabilities (Traynor 1998). These studies may therefore provide insight into how cultural, socio-economic, and geographical factors contribute to disparities between sexes in context of overall health. Although providing a vast examination of social, physical, economic, and physiological factors attributing to disparities in disease infection rates, the study does not provide a precise analysis regarding any specific population or demographic thus diluting its relevance to other cultures, societies, and demographics.

This study employs the use of national datasets and analysis that caters towards Australian society, demographics, and nuances that may impact and provide reasoning behind gender/sex disparities in invasive pneumococcal disease infection rates. Extensive research indicates that analysis of potential disparities in IPD notification rates between males and females have not been conducted using recent Australian data. This study will produce further insight into how the disease spreads and functions in Australian populations that therefore may contribute to present or future preventative and treatment measures.

SCIENTIFIC RESEARCH QUESTION

Does the male population of Australia exhibit a higher infection rate of Invasive Pneumococcal Disease than females?

SCIENTIFIC HYPOTHESIS

It is hypothesised that Invasive Pneumococcal Disease notification rates (per 100,000) are significantly higher in the male sex comparative to the female sex.

METHODOLOGY

Relevant data was collated from the National Notifiable Diseases Surveillance System [NNDSS]. Under this system, disease notifications from states and territories are directed to health authorities where the collected data is sorted and uploaded to publicly available platforms. This data was obtained by first selecting 'Notifications of a selected disease by age group, sex, and year' in a list of tools provided by the website. 'Pneumococcal disease (invasive)' was then selected and the 'Notification Rates (per 100,000 population)' option button was chosen. Data regarding sex and year was then extracted from 2001 to 2019 and transferred to a Table 1. Collected data was sorted into 'male' and 'female' columns with IPD notification rates for each sex in rows below. Data was graphically represented in a column graph. A two-sample t-test (one tailed) assuming unequal variances was performed (Figure 2) to determine if the mean male notification rates from 2001-2019 were significantly higher than female rates. This statistical process was conducted at a confidence level of 95%.

RESULTS

Through visual graphical representation of categorised data (Figure 1), it can be seen that there is a relatively sharp decline in IPD notification rates between 2004 and 2005. A noticeably constant trend can be observed between IPD notification rates of males and females across all examined years in the Australian population where the male sex exhibits proportionally consistent higher IPD notification rates as per 100,000 individuals. Despite slight discrepancies, data from 2006 to 2019 indicate patterns of gradual increase and decrease in IPD notification rates across all sexes. These gradual fluctuations run in succession approximately every 6 years from 2005-2011 and 2011-2017.

Results obtained from the performance of a one-tailed, two sample t-test (Figure 2) showed that male IPD notification rates were significantly higher than female notification rates. Data concerning male notification rates from 2001 to 2019 ($M = 9.15$, $SD = 2.15$) compared to female notification rates from 2001-2019 ($M = 7.40$, $SD = 1.40$) demonstrated significantly higher IPD notification rates, $t(31) = 2.97$, $p = 0.0028$.

DISCUSSION

This study is mainly regarding the relationship between sex and notification rates of IPD in the Australian population. As observed in graphical representation (Figure 1), a noticeable decline in IPD notification rates across both sexes can is evidently seen between 2004 and 2005. This coincides with the introduction and widespread funding of 23vPPV in the National Immunisation Program in approximately 2005 for all Australian adults. The results derived from statistical analysis techniques support the alternative hypothesis; indicating that the male sex exhibits significantly higher ($p<0.05$) IPD notification rates (per 100,000) in comparison to the female sex. Subsequently, it is therefore observed that males may be subjected to higher risks of IPD relative to females.

Results from this study's statistical analysis are comparative to previous studies on related discussions of sex related notification rate disparities. A study (Mukherjee, Sarkar, Saha and Chowdhury 2012) regarding gender difference in notification rates of tuberculosis conducted in India concluded that sex difference in notification rates was largely attributed to access of healthcare. It was proposed that women were more likely to seek medical aid and healthcare services whilst men had differential access to healthcare due to social and cultural stigmas. This indication is closely correlated to previously discussed literature (Vlassoff 2007) which concluded that social and cultural gender roles were a substantial factor in disparities amongst infection rates of tropical diseases. Results from this study may be an indication of the presence of similar societal and cultural stigmas in the Australian demographic.

Table 1. IPD notification rates per 100,000 individuals from Austraia from 2001 – 2019.

Year	Male	Female
2001	10.1	8.1
2002	14.3	10.5
2003	12.7	9.8
2004	13.7	9.9
2005	9.4	7.2
2006	8	6.1
2007	7.9	6.2
2008	8.6	6.7
2009	7.7	6.6
2010	8.3	6.6
2011	9.1	7.7
2012	8.2	7.8
2013	7.3	6.2
2014	7.1	6.2
2015	7	5.6
2016	7.5	6.3
2017	9.2	7.5
2018	8.7	7.5
2019	9	8.1

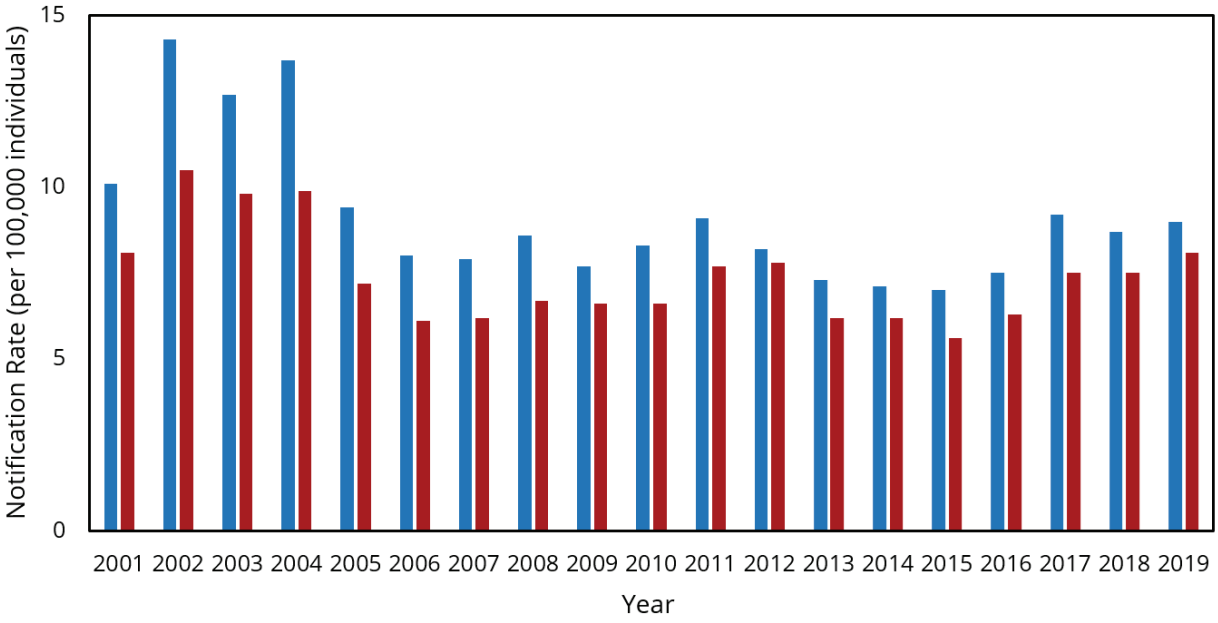


Figure 1. IPD notification rate per 100,000 individuals from Australia by year and sex (males [blue] and females [red]) from 2001-2019.

Figure 2. One-tailed, two sample t-test on IPD notification rates per 100,000 individuals in Australia between males and females.

	Male	Female
Mean	9.14	7.40
Variance	4.61	1.95
Observations	19	19
df	31	
t Stat	2.97	
P(T<=t) one-tail	0.00282	
t Critical one-tail	1.70	
P(T<=t) two-tail	0.00565	
t Critical two-tail	2.04	

The Australian blue-collar labour force is comprised of predominately males and equates to 30% of the overall workforce (Du Plessis, Cronin, Corney and Green 2012). It is hypothesised that through social and cultural evaluations, blue-collar workers are associated with strong alignments to typical male gender roles. These often comprise of tendencies to contain and/or suppress negative emotions (e.g. stress), passivity, and intemperateness. As a result, many male individuals are likely to compensate through the expression of stereotypical, orthodox, and hyper-masculine ehavioural traits. Studies show that the male gender was associated with risk-taking behaviour (Panno, Donati, Milioni, Chiesi and Primi 2017). Therefore, individuals pressured by stereotypes and societal and cultural norms may be more likely to commit actions of higher risks. Due to the epidemiology of Streptococcus pneumoniae, actions including congregations in large groups may lead to an increased transmission of the pathogen. Individuals may display acts of 'riskiness' by purposely exposing themselves to environments where IPD may be of higher threat. Studies show that the male sex exhibits higher competitiveness and is more often likely to use physical aggression whilst the female sex was more likely to use verbal aggression (Cashdan 1998). This increased physical contact and sociability amongst men (relative to women) may be a contributing factor to their significantly higher IPD notification rates (per 100,000 individuals). Furthermore, it is shown that male blue-collar workers were more likely to widen social networks after retirement (Macdonald, Brown and Buchanan 2001). Male dominance in national IPD notification rates may therefore be consequential of increased sociability, physical contact, and displays of risk taking behaviour.

Examination of Anglo-Australian participants with blue-collar occupations (Kolmet, Mariño and Plummer 2006) identified that majority expressed issues with alcohol and tobacco use; both of which are factors of susceptibility to IPD (Australian Government Department of Health 2020). This is supported by a survey conducted amongst Victorian men where it was determined that the demographic had a high prevalence of the use of tobacco and excessive alcohol consumption (Australian Institute of Health and Welfare 2015). Men in Australia were more likely to smoke daily and excessively (16.5% of national male population) when compared to females (11.1%of national female population) (Australian Bureau of Statistics 2020). Active and secondary smokers were found to be at an increased likelihood of developing respiratory tract infections (Bagaitkar, Demuth and Scott 2008). In particular, it was discovered that tobacco had negative impacts on the performance of immunological cells such as leukocytes which resulted in higher risks of infection. Reduction of harmless microflora in the nasopharynx due to smoking led to an increased risk of colonisation by Streptococcus pneumoniae along with Moraxella catarrhalis, Streptococcus pyogenes, and non-type B Haemophilus influenza (Brook and Gober 2005). This was largely due to weakened competition for space and resources. Therefore, it is evidently apparent that male bias in IPD notification rates may be explained by higher activities of smoking amongst the national male population.

Previously discussed studies indicate potential correspondence between testosterone and prevalence to infectious diseases (Bernin et al. 2014; Maurice, et al. 2016). Supplementary studies proposed that the male sex hormone has an immune-suppressive effect on the immune system whereas the female sex hormone (oestrogen) has an effect of immune-enhancement (Taneja 2018). It was concluded that women experienced less acute infections and had significantly stronger immunological responses to injected vaccinations. Results from this study can potentially be expounded by the discoveries of these past studies. However, due to their relatively recent emergence, it would be necessary to conduct further investigations on how testosterone can potentially affect the various processes of innate and adaptive immunity in men with a varied range of ages, levels of health, and demographics before definitive conclusions can be formed.

Patterns of increasing and decreasing fluctuation from 2005-2011 and 2011-2017 (Figure 1) may indicate the presence of new IPD serotypes that arise and are not effectively combated by 13vPCV and 23vPPV. Past potential occurrences of new IPD serotypes can be observed in England and Wales (Waight, Andrews, Ladhani, Sheppard, Slack and Miller 2015) where evidence suggested rising cases of IPD due to serotypes or variations that were not combated by 13vPCV. As a result, patterns seen in graphical representations of this study (Figure 1) could raise speculations regarding the efficacy of 23vPPV in the Australian population. Vaccine efficacy may have diminished over time as new variations of IPD have arisen. This theory is not conclusive, as a more tailored study would need to be conducted to deduce accurate, reliable and valid results.

The significance of this study is that it provides initial insights into the health-related issues of Australian males. The data presented offers a fundamental understanding of epidemiology and the impact of society and how it can affect the function of a disease in a population. Accordingly, prevention and treatment of IPD may not only encompass investigation on the pathogen, but also holistic factors such as way of life and social determinants which can have significant influences on an individual or a population's general health status (Braveman and Tarimo 1996). This study does not take into account the role of age, race, and socio-economic status due to limitations present in the acquired data set. Primary collection of data may be subject to human error, miscommunication, dishonesty, or malpractice. Notifications may vary due to judicial and legislative factors present in states and territories. Therefore, results may not be an accurate representation of the entire population of Australia. Further research into this area could lead to significant implications in the causes for sex related infection rate disparities. This may reduce gender/sex related inequalities amongst healthcare, socio-cultural spheres, and lifestyle activities thus potentially strengthening preventative measures relating to infectious diseases. Furthermore, it is an important aspect of epidemiology considering the current pandemic of COVID-19 and may refine prevention and treatment methods applicable to the disease.

CONCLUSION

Overall, it can be stated that the male population of Australia has statistically higher notification rates per 100,000 individuals of Invasive Pneumococcal Disease from 2001 to 2019 compared to the female population. Analyses of results compliment previous studies regarding the impact of societal factors and male sex hormones and their relationships to the susceptibility of individuals to infectious diseases. It was found that male bias in IPD notification rates showed strong connections to lifestyle activities such as smoking and tobacco usage and demonstrated potential associations and relationships to the impacts of commonly held social stereotypes. The connections between IPD and male sex hormones are inconclusive due to the theory's relatively new emergence. Investigations regarding such topics were minimal, thereby restricting affirmations of potential interrelatedness. Furthermore, this study may raise speculations on the degree of efficacy of 23vPPV; however, future investigations will need to be conducted to further these conjectures. It is also suggested that future research should be conducted on the factors that may cause or influence sex disparities in infectious diseases infection rates.

Discoveries stemming from these investigations can aid in the development and/or refinement of both preventative and treatment methods amongst procedures for infectious diseases thus positively impacting individuals and the greater community.

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Effect of high sodium intake on the blood pressure of different sexes and age groups

Jacinta Zixin Chen
Cumberland High School

The frequent utilization of low carbohydrate diet has led to an increase in salt consumption which affects blood pressure. An increase in the level of blood pressure above the optimal range of 140/80 mm Hg will lead to the development of hypertension which can cause cardiovascular mortalities. Today, increasing concerns are raised with regards to the effect of different diets between males and females as well as between young adults and older age populations. Hence, a secondary study was conducted to investigate the effect of different levels of sodium intake by looking at the blood pressure and urinary sodium level of males (n=745) and females (n=754) to find the relationship between them. This study revealed that there was a significant correlation between blood pressure and sodium intake. However, the amount of sodium intake may not be the main contributor accounting for the difference in blood pressure between males and females as younger populations tend to have a lower prevalence rate of hypertension compared to the older population.

LITERATURE REVIEW

The obesity rate around the world has increased to approximately 2.1 billion, which is about 30% of the world's total population. Obesity can cause a significant impact on the human body such as causing major changes in blood pressure [BP]. This has led to many people utilizing the low-carbohydrate diet to lose weight in order to reduce the risk associated with obesity. With a decreased carbohydrate intake, the levels of insulin fall significantly which results in the kidney excreting more sodium ions and water (Spritzler and Scher 2020). As a result, the sodium levels need to be raised. People that adopt the low carbohydrate diet require more than 5g of salt (2g of sodium) per day (Spritzler and Scher 2020). However, the World Health Organization [WHO] recommends the public to limit salt intake to less than 5g (2g sodium) per day (WHO 2020).

The human body requires a small amount of sodium to conduct nerve impulses, contract and relax muscles, and maintain the proper balance of water and minerals (Harvard T.H Chan School of Public Health 2020). Excessive sodium intake can result in heart disease, stroke and loss in calcium in the bone due to the inability of the kidney to function with excess sodium ions in the blood. As sodium ions accumulate, the body holds onto water to dilute the sodium ions. This increases the amount of fluid surrounding cells and the volume of blood in the bloodstream. This means more work for the heart and more pressure on blood vessels (Harvard T.H Chan School of Public Health 2020). Over time, the extra work and pressure can stiffen blood vessels, leading to high BP and heart failure.

High BP is also known as hypertension. It is a major risk factor for coronary heart disease, congestive heart failure, stroke and renal disease (Figure 1). Systolic blood pressure [SBP] measures the amount of pressure in arteries during the contraction of the heart muscle whilst diastolic blood pressure [DBP] refers to BP when a heart muscle is between beats (Madell 2020). Both SBP and DBP are important in determining the state of heart health. The optimal BP level is 120/80 mmHg or lower whilst 140/90 mmHg or higher indicates a high BP level. Higher BP indicates that one's heart is working too hard to pump the blood to the rest of the body (Madell 2020). Hypertension occurs when one's BP rises above 140/90 mmHg.

The rise in SBP continues throughout life, with its prevalence increasing with age and can lead to systolic hypertension (National High Blood Pressure Education Program 2003). Systolic hypertension is the most prevalent type of hypertension especially in those aged 50 or over, with an elevation in systolic but not diastolic pressure (Pinto 2007). On the other hand, DBP predominates either alone or in combination with SBP elevation; it is a more potent

cardiovascular risk factor than SBP until age 50. After that, it tends to level off over the next decade and may remain the same or fall later in life (National High Blood Pressure Education Program 2003). The incidence of hypertension becomes more prevalent with age (American Heart Association 1996) and hypertension is found in about 50 % of individuals above 55 years in many industrialized countries (Hermansen 2000). It was recently discovered that the age-related increase in BP appears to be a feature of industrialized or acculturated societies that may be associated with excessive dietary sodium intake.

Several studies have shown that salt reduction activates the salt conserving hormonal system (renin and aldosterone), the stress hormones (adrenalin and noradrenalin) and increases fatty substances (cholesterol and triglyceride) in the blood (Graudal, Hubeck-Graudal and Jurgens 2017). It is advised that individuals balance the amount of sodium intake as hyponatremia deficiency and hypernatremia toxicity are likely to occur when insufficient or excessive sodium intake occurs (Grillo et al. 2019). A study in the Archives of Internal Medicine (2011) found that people undertaking high sodium and low potassium diet are more susceptible to dying from heart disease. The study exemplified that people with the highest sodium intake had a 20%higher risk of death than those with low sodium intake (Harvard T.H Chan School of Public Health 2020). However, the relationship between the change in BP due to high sodium intake and the age of the population was not clarified.

The initial findings from the Dietary Approach to Stop Hypertension (DASH) Sodium Trial demonstrated that reduction of the sodium intake in diets decreased BP in participants. The study conducted by Karppanen and Mervaala (2006) found that the high salt intake levels largely explain the high prevalence of hypertension (Grillo et al. 2019) and that comprehensive reduction of salt intake can lower average BP levels substantially. During the past 30 years, the one-third decrease in the average salt intake has been accompanied by a more than 10mm Hg fall in the population average of both systolic and diastolic BP (Grillo et al. 2019). In the second (DASH) study of a controlled diet with one third sodium reduction, a reduction of 6.7 mm Hg in systolic BP and 3.5 mm Hg in diastolic BP was observed. However, the results did not specify whether different age groups would respond differently to the change in BP due to different sodium intake.

Most randomized control studies showcased that limitation of sodium chloride in food has been considered the critical change for reducing BP especially in older persons and in patients with hypertension (Hermansen 2000). Therefore, this study aims to investigate the effect of sodium intake on BP and to analyse whether the effect would have a significant difference between different age populations. The results could be used along with results from other related

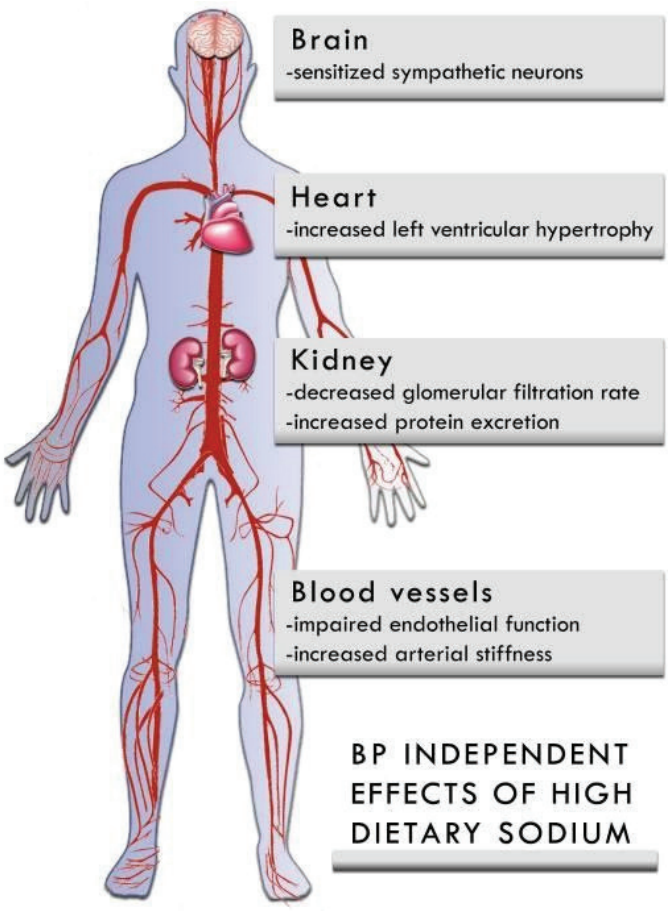

Figure 1. Effect of high dietary sodium causing damage to the target organ and may have direct effects on the brain, heart, kidneys and vasculature (Farquhar, Edwards, Jurkovitz and Weintraub 2020).

investigations to assist in determining whether diets with high sodium intake should be used as a customary way to lose weight without inflicting health problems. Verification of the hypothetical sodium-BP relationship and the effect on different age populations would support continuous attempts to lower sodium intake to reduce mortality rate and associated risk of diseases that cause death.

SCIENTIFIC RESEARCH QUESTION

How does high sodium intake affect the human BP and how does the effect vary between males and females of different ages?

SCIENTIFIC HYPOTHESIS

If a diet containing high levels of sodium is consumed, the human BP will increase. The amount of increase in BP will be larger for males of older age than younger age populations.

METHODOLOGY

Data Organisation and Processing

A raw dataset from a previous cross-sectional survey was analyzed (Du, Fang 2017). The dataset consisted of 7512 participants ranging from 18-69 years of age from Zhejiang Province China. The original data was collected using multistage sampling methods. The survey included face-to-face questionnaires and physical examinations among all participants. SBP and DBP measurements were performed according to internationally accepted measurement methods and quality control specifications with a calibrated electronic sphygmomanometer to ensure validity of the experiment. The raw data was processed, utilizing only relevant information including: the data of the participants who were asked to collect 24-hour urine to measure sodium and potassium levels to assess intake, the blood pressure, age and lifestyle. As a result, the data was comprised of the information of 1499 participants.

Statistical Analyses

The data was separated into males and females and further segregated into different age groups including young, middle-aged and older age and with each group consisting of people aged 18-35, 36-52 and 53-69 respectively. The mean SBP and DBP (mm Hg), as well as the 24-hour urinary sodium (mmol/day) were found. The urinary sodium was converted from mmol/day into grams/day using the formula (Algeria-Ezquerra 2020):

$$Na\ (mg/day) = Na\ (mmol/day) \times 23$$

Then, the sodium intake of males and females were compared against the WHO's recommended level of sodium intake. The smoking status and the average weight between females and males were compared.

A two-sample t-test assuming unequal variances was used to compare the SBP & DBP and urinary sodium of the different age groups between males and females. This was conducted to investigate whether there is a significant difference between the mean BP and sodium intake for different age populations to determine the effects of sodium intake on different age groups. BP and the amount of urinary sodium for different age groups were also compared using regression statistical analysis to investigate whether there is a significant correlation between the variables. The statistical analysis was carried out with a 5% significance level.

RESULTS

Blood pressure rates between males and females of different age groups

The male (n = 745) and female (n = 754) participants and were split into three age groups. The young age group consisting of people aged from 18 to 35 had the lowest average rate of BP for males (M = 125/79, SD = 15/11) and females (M = 113/74, SD = 11/8) among the three age groups. There was a significant difference in the BP between males and females, with SBP ($t(432) = 10.09$, $p = 1.18\times10\text{-}21$), as well as DBP ($t(429) = 5.61$, $p = 3.66\times10\text{-}8$). The young age group also had the lowest number of people with hypertension which indicated a reduced risk of heart disease (Table 1; Table 2).

The middle-aged group consisting of people aged from 36 to 52 had a relatively higher BP compared to young groups with males (M = 132/84, SD = 16/11) and females (M = 122/78, SD = 16/10). There was a significant difference in BP between males and females with SBP ($t(502) = 6.61$, $p = 9.54\times10\text{-}11$), and DBP ($t(489) = 8.16$, $p = 2.78\times10\text{-}15$). There was approximately 39% of males with hypertension and 20% of females with hypertension in this age group (Table 1; Table 2).

The older population consisting of people aged from 53 to 69 had the highest BP of males (M = 140/85, SD = 18/11) and females (M = 136.81, SD = 19/11). There was a significant difference among their SBP ($t(521) = 2.70$, $p = 0.0073$) and DBP ($t(522) = 4.21$, $p = 2.99\times10\text{-}5$). This age group also had the highest rate of people with hypertension including 65% of males and 57% of females (Table 1; Table 2).

Sodium Intakes for males and females of different age groups

The sodium intake for young males (M = 3.81, SD = 1.80) and young females (M = 3.91, SD = 1.64) did not reveal a significant difference,($t(464) = -0.65$, $p = 0.52$) (Table 3; Table 4). There was no significant difference in sodium intake for middle aged males (M = 3.78, SD = 1.62) and middle aged females (M = 3.78, SD = 1.70),($t(504) = -0.07$, $p = 0.94$) (Table 3; Table 4). The sodium intake for older age males (M = 3.99, SD = 1.81) and older age females (M = 4.00, SD = 1.77) did not reveal a significant difference ($t(521) = -0.31$, $p = 0.76$) (Table 3; Table 4).

BP and urinary sodium

There was a weak positive correlation observed between the SBP and the urinary sodium for males aged from 36 to 52 ($r \approx 0.1$), the SBP and urinary sodium for females aged from 36 to 52 ($r \approx 0.3$) and the DBP and urinary sodium for females aged from 36 to 52 ($r \approx 0.2$). This represented that when there was an increase in urinary sodium, meaning an increase in sodium intake, the BP also increased (Figure 2; Figure 3). There was a significant correlation ($p < 0.05$) between the DBP and urinary sodium for both young age males and females and between the SBP and urinary sodium for young age females (Figure 4; Figure 5).

Smoking Status and Weight

In total, there were more males (n = 279) involved in smoking than females (n = 2) amongst all age groups and males weighed more than females across all age groups (Table 5; Table 6).

Table 1: Information from selected male participants in different age groups.

Age group	**Sample size** (n=745)	**Mean BP ± SD** (SBP/DBP mmHg)	**Proportion with hypertension**
18-35	237	125/79 ± 15/11	15%
36-52	246	132/86 ± 16/11	30%
53-69	262	140/85 ± 18/11	55%

Table 2. Information from all female participants involved in the survey.

Age group	**Sample size** (n=754)	**Mean BP ± SD** (SBP/DBP mmHg)	**Proportion with hypertension**
18-35	232	113/74 ± 11/8	4%
36-52	260	122/78 ± 16/10	25%
53-69	262	136/81 ± 19/11	71%

Table 3. Urinary sodium collection for male participants and their calculated sodium intake.

Age group	**Average urinary sodium** (mmol/day)	**Estimated sodium intake** (g/day)
18-35	165.56 ± 78.23	3.81 ± 1.80
36-52	163.96 ± 10.68	3.78 ± 1.62
53-69	171.88 ± 80.34	3.99 ± 1.81

Table 4. Urinary sodium collection for female participants and their calculated sodium intake.

Age group	**Average urinary sodium** (mmol/day)	**Estimated sodium intake** (g/day)
18-35	170.04 ± 71.1	3.91 ± 1.64
36-52	1164.43 ± 73.68	3.78 ± 1.70
53-69	174.00 ± 76.80	4.00 ± 1.77

Table 5. Answers to whether male participants smoke and their average weights.

Age group	**Yes** (%)	**Used to** (%)	**Never** (%)	**Mean Weight** (kg) ± SD
18-35	64	9	164	71 ± 12.76
36-52	108	6	131	72 ± 10.74
53-69	107	21	134	71 ± 9.31
Total	279	36	136	

Table 6. Answers to whether female participants smoke and their average weights.

Age group	**Yes** (%)	**Used to** (%)	**Never** (%)	**Mean Weight** (kg) ± SD
18-35	0	0	232	55.92±7.76
36-52	1	1	258	59.55±9.37
53-69	1	0	261	60.33±8.82
Total	2	1	751	

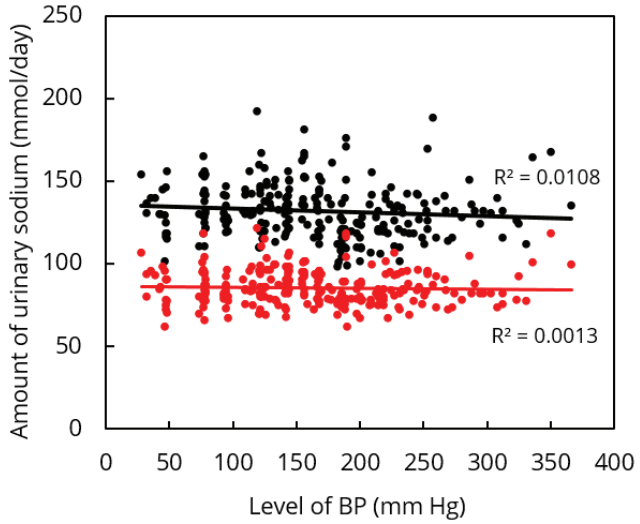

Figure 2. SBP (black) and DBP (red) – Urinary Sodium relationship for males aged 36-52.

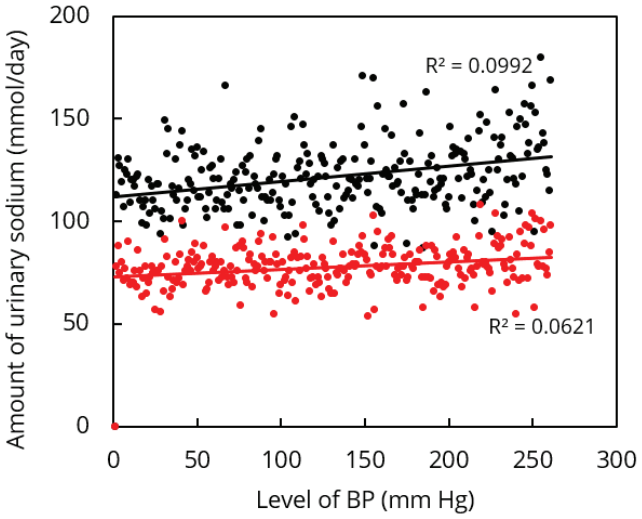

Figure 3. SBP (black) and DBP (red) – Urinary Sodium relationship for females aged 36-52.

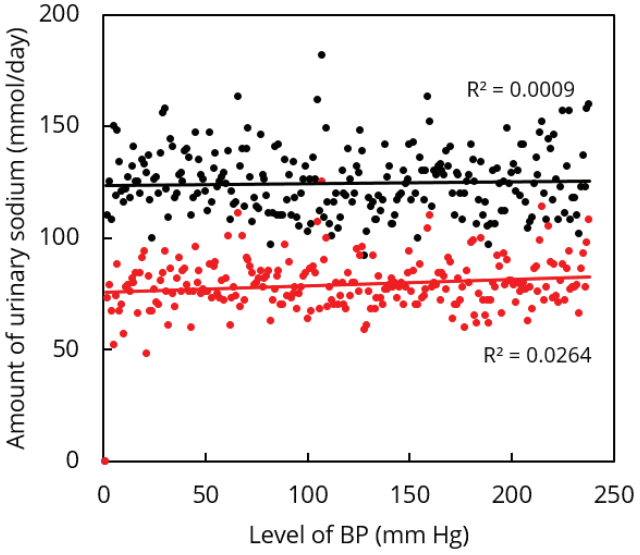

Figure 4. SBP (black) and DBP (red) – Urinary Sodium relationship for males aged 18-35.

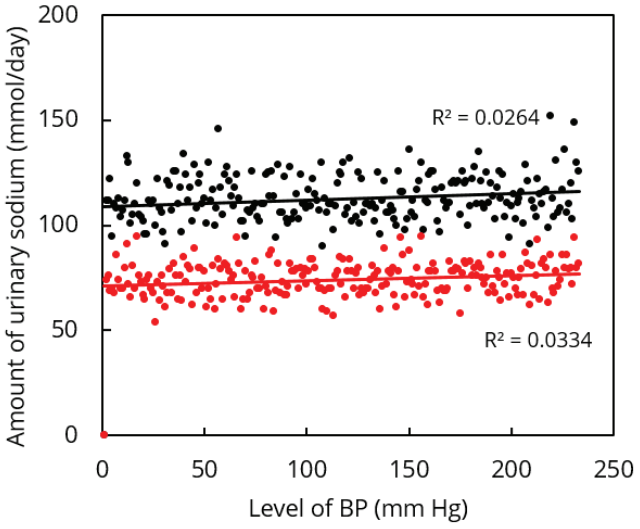

Figure 5. SBP (black) and DBP (red) – Urinary Sodium relationship for females aged 18-35.

DISCUSSION

Effect of sodium on BP of older people

Hypertension has been recognised as a significant risk factor for cardiovascular disease, which has become a nationwide epidemic especially in China (Du et al. 2019). The results showcased that the average urinary sodium excretion among the male participants ranged from 165.56 to 171.88 mmol/day which is approximately 3.81-3.99 grams of sodium intake (Table 3) and for female participants, their average urinary sodium excretion ranged from 170.04 to 174.00 mmol/day which is approximately 3.91-4.00 grams of sodium intake (Table 4). This level is higher than the recommended level of sodium intake of 2 grams per day issued by the WHO in 2012. The increase in sodium intake correlates with an increased level of blood pressure above the normal range of 140/80 mmHg (Xu et al. 2014). The younger population had a lower blood pressure rate compared to the older populations (Table 1, Table 2) which corroborated with the proposed hypothesis. Hence, this indicated that the average blood pressure rate increases as the amount of sodium intake increases as people get older. This therefore showcases that the effect of sodium on BP for older people is higher.

Suggestions on Salt Intake

Salt intake is relatively high in China mainly because of the tradition of adding excessive salt to foods, especially during cooking and the high consumption of soy sauce (Zhou et al. 2003). A recent study of dietary sources of sodium in different countries suggested that most dietary sodium (76%) in China was from salt added in home cooking (Anderson et al. 2010) and soy sauce (15.0%). In comparison, most of the salt in western countries (75–80%) is derived from processed foods (Ortega et al., 2010). This was demonstrated in the results where all participants had a higher sodium intake as the data was collected from participants in China. A study published in Global Health Research (2020) stated that the sodium intakes were the highest in East Asia, Central Asia and Eastern Europe with the mean >4.2 g/day and in Central Europe and the Middle East/North Africa it was 3.9–4.2 g/day. Regional mean sodium intakes in North America, Western Europe and Australia/New Zealand ranged from 3.4 to 3.8 g/day (Powles et al. 2020). This enhanced that there was a higher sodium intake in Eastern countries.

Blood Pressure and the Level of Sodium Intake

The results from Figure 2 and Figure 3 illustrated the relationship between the level of sodium intake and the blood pressure for middle age males and females. Figure 4 and Figure 5 demonstrated that there was a significant correlation between the level of sodium intake and the BP. It also showed that the sodium intake and the rate of blood pressure in females were lower than in males in general. The result aligned with the hypothesis and was also supported by the experiment conducted in Yantai, China, which discovered that the intake and excretion of sodium were higher among males (218.3±81.4 mmol/d) as compared to women (183.8±69.8 mmol/d) due to the overall higher food intake and differences in dietary habits (Xu et al. 2014). This result reveals a relatively higher sodium intake than the results obtained in this study.

The findings highlighted the difference in the prevalence of hypertension between genders and age groups, suggested that males are more likely to develop high BP than females and the prevalence greatly increases with older populations. However, the mean sodium levels between males and females for all different age groups were not significantly different ($p > 0.05$). While males and females had similar amount of sodium intake, the regression analysis demonstrated a significant weak positive linear correlation ($r = 0.18$) between the urinary sodium and the blood pressure in both male and female population (Figure 5). This aligned with the results from the study conducted in Yantai which had SBP ($r = 0.25$, $p = 0.0006$) and DBP ($r = 0.22$, $p = 0.0020$) that were positively and significantly correlated with 24-hour urinary sodium excretion (Xu et al. 2014). These suggested that the difference in blood pressure rate from the two groups could be due to other factors such as smoking and exercise patterns.

It was evident that more males tend to smoke and would weigh more than females (Table 5, Table 6). This could suggest that smoking and obesity could also be a contributor to high blood pressure in this case. Therefore, based on the findings, it is advised for a reduction in the use of low carbohydrate diet for both males and females to reduce their daily salt consumption by 1-2 grams, especially for older age populations. Furthermore, for males, it is also advised that they limit the amount of tobacco consumed to achieve prevention and control of hypertension. Salt reduction is possibly most effective in the elderly because of decreased arterial compliance and hence a decrease in arterial blood volume which leads to a larger drop in BP (Pinto 2007).

This study was conducted to gain a better understanding of the impact of sodium intake on blood pressure and how it affects different ages and sexes which could be useful for future research in how to better control and prevent hypertension. A population-wide fall in systolic BP of 2 mmHg has been predicted to lower stroke mortality by 10% and ischemic heart disease and other vascular diseases by 7% (Prospective Studies Collaboration 2002). Furthermore, because of many risk factors for hypertension as well as different lifestyles employed by different people, the way to prevent and control hypertension in the future must be diversified and that salt intake reduction may be an essential and indispensable method (Du et al. 2019).

Since the data was obtained from a Chinese source which consisted of information based purely on Chinese participants, possible bias could result in the findings not being applicable to general populations around the world. Furthermore, the small sample size limits the precision to attain a more accurate and valid analysis to determine the effect of sodium intake on BP of different genders and age groups.

Future investigation regarding similar discussions may seek to use numerous large sample sizes consisting of participants from different cultural backgrounds. This data should be collected and analyzed to seek findings that could apply to the general public and have more precise results. The urinary sodium should be collected numerous times using professionalized methods to avoid volatility and ensure validity and hence can allow a better determination of the level of sodium consumed by the participant. Future research could look at different treatments that could be used to control or treat hypertension for different age groups and investigate further into treating other diseases.

CONCLUSION

There is a significant correlation between the rate of BP and urinary sodium for the young age group that as the amount of sodium intake increases, the blood pressure rate also increases, suggesting that higher sodium intake may

lead to an increase in BP. Once a person's BP exceeds the optimal range of 140/90 mmHg, hypertension will be developed which can lead to cardiovascular mortalities. The prevalence of hypertension is more common in males with older age (67%), meaning males on average had a higher range of BP than females. The younger population had a lower blood pressure rate compared to the older populations overall. Since the amount of sodium intake between males and females were not significantly different ($p>0.05$), this indicated that the difference in blood pressure rate from the two groups could be due to other factors such as smoking and exercise patterns. Based on the findings, it is advised for an overall reduction in sodium intake for both males and females in their diet. Further research is required to establish effective control with regards to the prevalence of hypertension.

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The correlation between hypertension and mind wandering

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Data attributed to mind wandering caused by hypertension is limited. In this study, research is compiled, and data is analysed to attempt to develop a causative link between both hypertension and mind wandering. Descriptive and statistical analysis is included in the data analysis, utilising data from the NYC-Q study conducted by Max Planck Institute. 199 participants were included in the study, showing no significant changes before the first and second measurements of blood pressure. A mind wandering questionnaire was carried out, with responses varying, with a weak relationship (r = 0.25; r = 0.31; r = 0.12; r = 0.23) established between the average of the participants answer to each question and the blood pressure measurements. These results provide evidence to suggest that hypertension is not a causing factor of mind wandering.

LITERATURE REVIEW

There are few studies that show a link between mind wandering and hypertension, both characterised in school-aged adolescents. For school-aged adolescents, a contributor to hypertension is the excessive stress they present (Danasekaran et al. 2016), which is also shown to be linked to mind wandering (Ottaviani et al. 2016).

Mind wandering is defined as the ability of the brain to escape the here and now (Ottaviani et al. 2016). Mooneyham & Schooler (2013), analysed many research papers, and found that mind wandering may be described as a failure of cognitive control, as well as being often correlated with reading comprehension performance. They also found that mind wandering is often detrimental to many tasks, ranging from simple vigilant tasks to sitting an important exam, along with causing a comprehension deficit. Furthermore, the study found that individuals are less happy when they are mind wandering compared to when they are not, though does not list any possible causes or suggestions for causes.

A suggested reason for mind wandering is to anticipate and plan relevant future goals, due to the large number of thoughts during mind wandering are prospective in nature.

Mind wandering is often measured through cognition questionnaires, including the Mind Wandering Questionnaire [MWQ], the Daydream Frequency Scale [DDFS] and the Mindful Attention and Awareness Scale [MAAS] (Mrazek et al. 2013). Another common example of a cognition questionnaire used to measure mind wandering is the New York Cognition Questionnaire [NYC-Q]. The NYC-Q was developed to assess the content and form of an individual's experiences while completing a specific task or activity just prior to completion (Gorgolewski et al. 2014 as cited in Max Planck Institute's Supplementary Materials). The NYC-Q, as a self-reporting questionnaire of a total 31 questions, is separated into two sections, the first measuring the content of thoughts (question 1-23), and the second measuring the form of thoughts (question 24-31). This is scored on a nine-point Likert scale (Figure 1). The first section of the

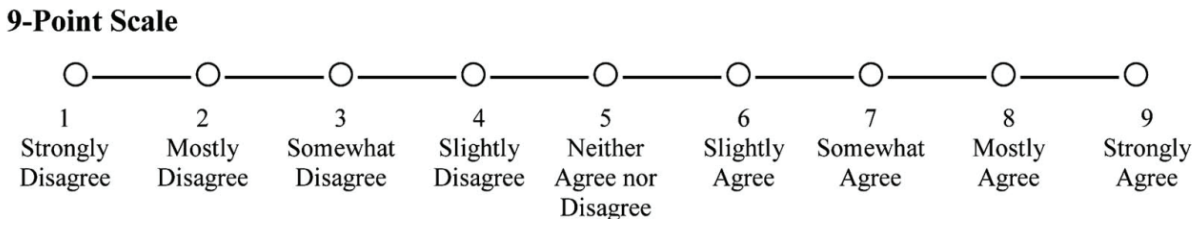

Figure 1. 9-Point Likert Scale (Eutsler & Lang 2015).

questionnaire scales from 1, being "completely did not describe my thoughts", to 9, being "completely did describe my thoughts", while the second section of the questionnaire scales from 1, being "completely does not characterise my experience" to 9, being "completely characterises my experience".

This study will have a proposed focus on adolescents in a school setting, to determine if mind wandering is both present in students, and is detrimental to the ability of students to focus when they experience a state of hypertension, such as after physical activity or stress.

Perseverative cognition is used as an umbrella term encompassing ruminative and worrisome thoughts. Ottaviani et al. (2015) aimed to relate mind wandering and perseverative cognition in major depression and hypothesised that perseverative cognition would be associated with higher levels of cognitive, behavioural and autonomic inflexibility compared to mind wandering and being on task. It was found that both the control group and the group with major depressive disorder were more anxious, sad, tired, and angry during perseverative cognition compared to mind wandering and being on task. An important note from this study is that the ability to adaptively let our mind wander without ruminating is critical to mental health. It is interesting to note that some papers by this author suggest perseverative cognition and mind wandering are completely separate (Ottaviani et al. 2017), while others say that perseverative cognition is a sub-category of mind wandering (Ottaviani et al. 2015).

A causing factor of many cognitive functioning issues is hypertension (Kupferman et al. 2012). A hypertensive state is defined in adolescents as systolic and/or diastolic blood pressure above the 95th percentile for age, gender and height on three separate occasions (Webb, Shatat and Miyashita 2014). Resting state, often the initial blood pressure measurement taken in a study, should be considered as a period of sitting or standing with no preceding strenuous exercise to induce a heightened blood pressure (Ottaviani et al. 2016). Systolic blood pressure is how much pressure blood is exerting against artery walls when the heart beats, while diastolic blood pressure is how much pressure blood is exerting against artery walls while the heart is resting between beats. Normal blood pressure is considered to be numbers less than 120/80 mm Hg (expressed as systolic blood pressure/diastolic blood pressure millimetres per mercury). Danasekaran et al. (2016) found that hypertension in adolescents is derived from a relationship between genetic, environmental and behavioural factors, including stress and hereditary effects. It also found that the issue of hypertension in adolescents is increasing in prevalence. Lande, et al. (2003) viewed the cognitive scores of children with elevated blood pressure compared to those with normal blood pressure. It was found that children with elevated systolic blood pressure had lower scores for digit span, block design and mathematics. Kupferman et al. (2013) found that students with hypertension perform worse on tasks in which they are required to learn and remember word lists, repeat lengthy sentences or identify relationships between abstract pictures, in comparison to those without hypertension.

A research study from The Society of Behavioural Medicine showed the difference of blood pressure activity during functional and dysfunctional types of repetitive thinking (Ottaviani et al. 2016). The results show that when tested on mind wandering, both systolic and diastolic blood pressures increase slightly from a resting state (baseline), through blood pressure heightening due to a stimulus (reactivity), until a period where the patient is no longer responding to a stimulus (recovery). For perseverative cognition, both systolic and diastolic blood pressures increase from baseline to reactivity, then results see diastolic blood pressure decrease from reactivity to recovery, while systolic blood pressure increases from reactivity to recovery. For problem solving, both systolic and diastolic blood pressure increase from baseline to reactivity, then decrease from reactivity to recovery. The main findings of this literature based on mind wandering is that it presents itself to associate with both detrimental (consequence of depressive state, dysphoria) and beneficial (increased cardiovascular, autonomic system activity) outcomes in adolescents, with common causes being stress, mood and environment. The literature finds that there is an increasing prevalence of adolescents with varying types of hypertension (acute, primary, secondary, labile), caused by factors including stress and hereditary effects. From this research, the correlation between adolescents and hypertension and adolescents and mind wandering is made evident, though there is a gap in the research, with no established paper showing hypertension as a definitive causative factor of mind wandering in adolescents.

SCIENTIFIC RESEARCH QUESTION

Does hypertension cause an increase of mind wandering in healthy adolescents?

SCIENTIFIC HYPOTHESIS

If adolescents have hypertension, there will be an increased prevalence of mind wandering.

METHODOLOGY

Data Collection

This data was derived from the "Leipzig Study for Mind-Body-Emotion Interactions" [LEMON]. The criteria for data ensured that of the 227 patients participating in LEMON, the selected participants' data for the NYC-Q and blood pressure monitoring for left arm measurements was present

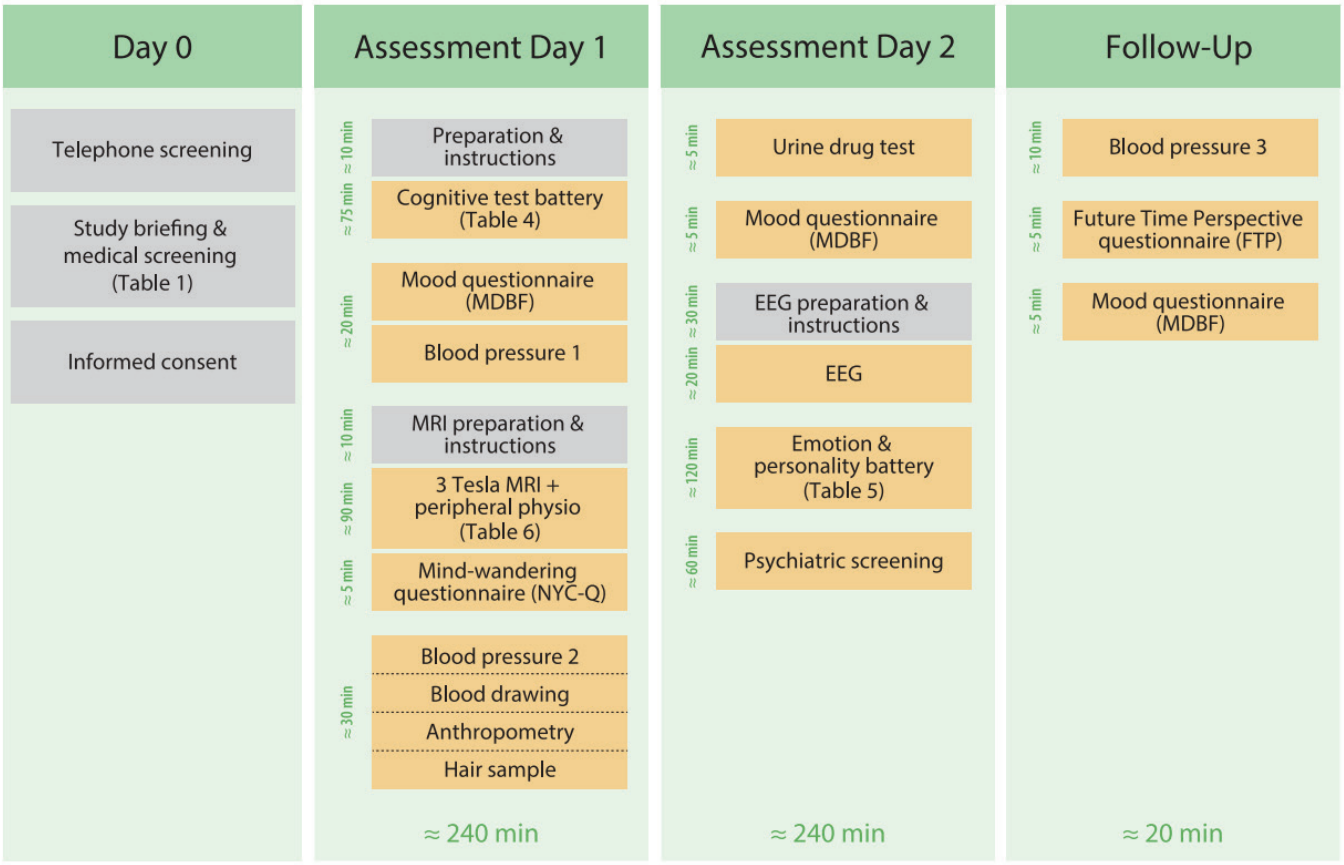

Figure 2. Chronological order of data collected as part of the LEMON study. Data used for this paper were limited to Blood pressure 1, NYC-Q responses and Blood pressure 2.

and complete. There was consideration for the age of participants, with groups in the dataset being 20-35 and 59-77. There was insufficient data to further refine the sample size for the youngest participants of the study, further refined by LEMON to ages 20-25, the closest age group to relate to adolescents. The final number of selected participants was 199. The blood pressure results selected were those taken immediately before the Functional Magnetic Resonance Imaging (fMRI) scanning and after the NYC-Q testing, which occurred sequentially. Measurements of blood pressure that were ignored include pulse pressures, the difference between systolic blood pressure and diastolic blood pressure, the measurements of blood pressure taken on right arm as there is no difference between the measurements on right and left arm ($t(457) = -0.71551$, $p = 0.474661$), and the third measure of blood pressure, as they are not relevant to this study.

Statistical Analysis

All statistical tests were undertaken using Excel v.1909 (Microsoft Office 365). 2 two-sampled t-tests were used for the comparison of both diastolic and systolic blood pressure pre and post fMRI, assessing any change in results. A selection of 199 participants were included in the t-test, being the group aged 20-25. Correlations are used to compare the average of each participants' answers to the first section of the NYC-Q against systolic and diastolic blood pressures before and after the completion of the fMRI and the NYC-Q. The first section was used due to the nature of the questions directed at the contents of thoughts, as opposed to the second section, which focussed on the form of thoughts. These are individually graphed to show any trend, and a Pearson correlation analysis is performed.

Descriptive Statistics

Special consideration was made for question 22 in the first section of the NYC-Q: "I thought about personal worries", as this would possibly induce a state of stress-caused hypertension. For this question, a tally was made of all responses of 1 through 9 and is compared to whether the blood pressure increased or decreased.

RESULTS

The results for the first diastolic blood pressure (M = 75, SD = 11.4) and the second diastolic blood pressure (M = 75, SD = 13.7) show no significant difference between each measure, (t(146) = 0.015, p = 0.98).

The results for the first systolic blood pressure (M = 126.1, SD = 14.3) and the second diastolic blood pressure (M = 124, SD = 13.7) show no significant difference between each measure (t(146) = 0.898, p = 0.37).

The average response values from NYC-Q and systolic blood pressure measurements before the fMRI show a weak correlation, r(1) = 0.25, p = 0.0003 (Figure 3).

The average response values from NYC-Q and systolic blood pressure measurements after the NYC-Q show a weak correlation, r(1) = 0.31, p = 5.9x10-16 (Figure 4).

The average response values from NYC-Q and diastolic blood pressure measurements before the fMRI show a very weak correlation, r(1) = 0.12, p = 0.09 (Figure 5).

The average response values from NYC-Q and diastolic blood pressure measurements after the NYC-Q show a weak correlation, r(1) = 0.23, p = 0.001 (Figure 6).

DISCUSSION

Adolescence is a time of rapid development in areas such as problem solving, information processing and judgement. Therefore, it is vital that the body is healthy throughout the course of teenage years (Madaeva et al. 2016).

Statistical analysis shows a very weak correlation between blood pressure and mind wandering. Comparison of four measures of blood pressure indicate very small differences in blood pressure measurements before and after the fMRI and NYC-Q.

Systolic blood pressure measured before the fMRI shows points corresponding to approximately 7-8 for the average of answers and blood pressure at approximately 120mm Hg (Figure. 3). These participants sit a normal systolic blood pressure range without having undergone any mind wandering activities. There is a point at approximately (3,195), an extremely high reading of blood pressure, suggesting this participant may have pre-existing hypertension issues, though the low average of answers on the Likert scale provides evidence against this study's hypothesis.

Systolic blood pressure measured after the NYC-Q shows participants who answered an average of 7-8 and approximately 120mm Hg, indicating that these participants

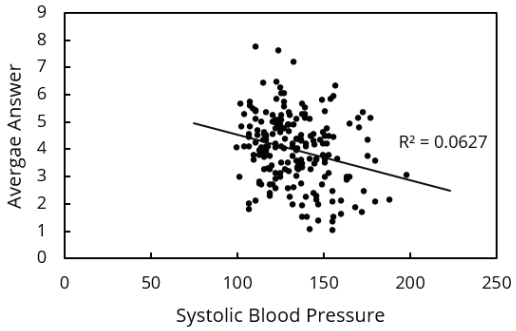

Figure 3. Average response values from NYC-Q vs. left arm systolic blood pressure measurements before fMRI.

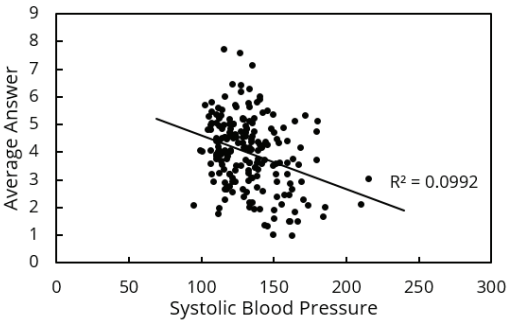

Figure 4. Average response values from NYC-Q vs. left arm systolic blood pressure measurements after NYC-Q.

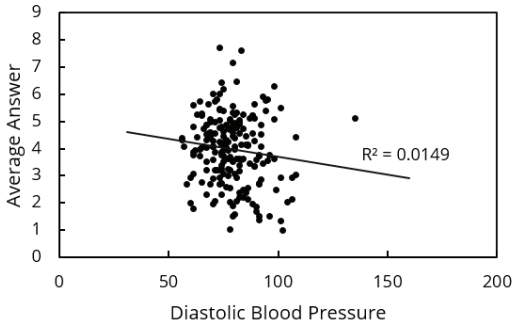

Figure 5. Average response values from NYC-Q vs. left arm diastolic blood pressure measurements before fMRI.

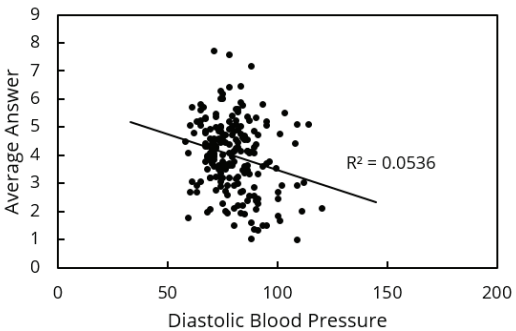

Figure 6. Average response values from NYC-Q vs. left arm diastolic blood pressure measurements after NYC-Q.

	1	2	3	4	5	6	7	8	9	Total
Increased SBP	55	5	4	3	3	3	1	2	10	86
Decreased SBP	63	18	5	8	3	6	5	2	3	113
Total	118	23	9	11	6	9	6	4	13	199

Table 1. NYC-Q question 22 response value based on 9-point Likert Scale (n=199) where SBP = Systolic Blood Pressure and DBP = Diastolic Blood Pressure.

sit at a normal blood pressure level after having undergone mind wandering activity and do not present hypertensive blood pressure levels (Figure 4).

Similar trends are evident in diastolic blood pressure measurements, where there is a general cluster of where participants lie on the graph, with some notably further away from the regression line. Diastolic blood pressure measurements taken before the fMRI shows points corresponding with an average of answers at approximately 7-8 and blood pressure levels between approximately 70 and 85mm Hg, indicating that these participants sit at a normal diastolic blood pressure range before having undergone any mind wandering activities (Figure 5).

Diastolic blood pressure measurements taken after the NYC-Q shows points corresponding with an average of answers at approximately 7-8 and blood pressure levels at approximately 70-80mm Hg, showing these participants did not present hypertensive blood pressure states (Figure 6).

The dataset used is of an age group of that is not an exact representative of an adolescent population, required for conclusive links to be drawn in this study. The data can then be related instead to a tertiary education setting, particularly for the group aged 20-25. In conjunction to the data analysis, reading and analysing of the fMRIs may be utilised in future studies to detect changes in the blood flow in the brain, determining the active section/s of the brain. The dataset study did not measure blood pressure throughout both the fMRI and the NYC-Q, which, in further research, would be beneficial to find elevated blood pressure and increased mind wandering activity. Further research would see first-hand data being used to select participants of an adolescent age, and gain the desired data on blood pressure measurements. The focus on the question 22 "I thought about personal worries" indicates a potential cause of stress that can be related to the causation of a stress-induced hypertensive state, labile hypertension. Descriptive statistics show that most people answered this question with "1" to indicate they did not at all think about personal worries, and those that did think about personal worries were more likely to have a decrease in blood pressure (Table 1). This trend does not support the hypothesis of the study, instead indicating that most people, with both increased and decreased blood pressure did not think about a personal worry at all. Those that did mind wander, thinking about a personal worry, are almost evenly spread across both increased and decreased blood pressure. Further study on stress as a causative agent of both mind wandering and blood pressure can be undergone to support and be used with this study. This further study can then be applied and used in a school setting for the benefit of learning students.

An issue encountered in the data collection and refining process was that there were numerous participants who did not have complete results for NYC-Q. These participants were omitted from the data analysis. The dataset is from a reliable source, with many authors to authenticate the work carried out. There is ensured validity specified in the dataset study (Babayan et al. 2019), ensuring that all data is manually double-checked. The NYC-Q, a German questionnaire, was translated by a professional translator to ensure there was no mistranslation. It was also ensured that the participants in the dataset had no existing health issues prior to partaking in this study.

The results of this study cannot be considered conclusive. Kupferman et al. (2011) summarised the knowledge of neurocognitive functioning in hypertensive children. The paper defines executive functioning as higher cognitive activity that includes skills needed for purposeful, goal-directed behaviour, found to be affected by the prefrontal cortex, similar to mind wandering. The paper also finds that adults displaying hypertension score lower on neurocognitive performance tests compared to those without hypertension, and occur consistently with effects on attention and learning and memory. The paper shows many studies that find an

evident relationship between hypertension and other aspects of brain functionality, though there is no mention of mind wandering, and only mentioning the related concept of attention very briefly.

This study found that there was no significant difference to the blood pressure measurements before and after the fMRI and NYC-Q, and hypertension cannot be found to conclusively be a causative factor any mind wandering activities. It can, however, make suggestions for further research in finding a definitive answer or conclusion to the question of "Does hypertension cause an increase of mind wandering in healthy adolescents?" as posed at the beginning of the paper. Suggestions include ensuring the participants are in a large sample size and are adolescents, and recording blood pressures at baseline, reactivity and recovery periods in relation to the time of mind wandering activities.

CONCLUSION

The hypothesis was that if adolescents have hypertension, there will be an increased prevalence of mind wandering. The results of this study have not conclusively proven or disproven this hypothesis, though has shown a very weak correlation, that further research may find to suggest that there is limited change to blood pressure when exposed to a mind wandering state or activity. To run the same experiment again with alterations to the method and with aims of the dataset to answer the question would be very beneficial in answering the research question. The gap in literature is identified as the lack of research on hypertension as a causative factor of mind wandering.
As the findings are not conclusive, there are no implications of these that can be applied to the proposed setting of a classroom of adolescents, however research into this field of study can be proposed and focused on in this type of setting.

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