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Knowledge, attitudes and opinions towards measles and the MMR vaccine across two New York City communities

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KNOWLEDGE, ATTITUDES AND OPINIONS TOWARDS MEASLES AND THE MMR VACCINE ACROSS TWO NEW YORK CITY COMMUNTIES

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Thanks Mom, Dad, Alex and Chloe. And to all my friends, family, teachers and mentors.

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ABSTRACT

Measles is a potentially deadly illness that has been declared no longer endemic in the United States of America since 2000.[1] However, in the past few years, imported cases of the measles have continued to cause hospitalization and deaths among those citizens who remain unvaccinated, or have waning immunity, against measles, especially children. The Measles, Mumps and Rubella (MMR) vaccine has been available since 1963 and is routinely given to children in the first two years of life.[1] Endemic cases of measles are increasing each year, specifically in undervaccinated communities. In 2018-2019, there was an outbreak of measles in the Williamsburg neighborhood of Brooklyn, New York. Investigating the knowledge, attitudes and opinions on the measles virus and the MMR vaccine in the Williamsburg neighborhood may facilitate discussions that could increase the vaccination rate among its population, as well as elucidate more effective strategies for vaccination in the future. Comparing attitudes from the Williamsburg neighborhood with a population across the Hudson River, in the East Village, which has previously had higher rates of vaccination, could shed light on how to target and tailor vaccination campaigns to different populations in New York City moving forward.[2–4]

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LIST OF ABBREVIATIONS

AAP ..... American Academy of Pediatrics

ADEM ..... Acute Disseminated Encephalomyelitis

BPHC ..... Boston Public Health Commission

BU ..... Boston University

CDC ..... The United States Center for Disease Control

ISO ..... International Standards Organization

IgG ..... Immunoglobulin G

IgM ..... Immunoglobulin M

MIBE ..... Measles Inclusion Body Encephalitis

MMR ..... Measles, Mumps and Rubella Vaccine

MMRV ..... Measles, Mumps, Rubella and Varicella Vaccine

MMRSI ..... Measles, Mumps, Rubella Severity Index

MSI ..... Measles Severity Index

NYC ..... New York City

NYDPH ..... New York Department of Public Health

SSPE ..... Subacute Sclerosing Panencephalitis

WHO ..... World Health Organization

INTRODUCTION

Background

Measles is a highly contagious virus that primarily affects people who are not immune to it. Ninety percent of people who are exposed and do not have immunity will develop measles.[5] Measles is responsible for over 140,000 deaths every year worldwide, mostly in children under the age of five.[6,7] However, prior to the creation and widespread administration of the MMR vaccine, it caused over two million deaths annually.[6]

Recently, the United States has seen an increasing number of measles cases. The cases have mostly been found within New York City (NYC), which caused a public health emergency to be declared in April of 2019. This included Mayor de Blasio placing mandatory vaccination requirements on certain zip codes.[8] The outbreak began in October and can likely be traced back to Israel where a young unvaccinated child became infected and then brought the disease back to the United States. This one case can be traced to more than 285 cases of measles in New York State alone.[8]

This increase in endemic transmission in 2019 has put the United States at risk of losing their status of measles elimination.[8,9] The WHO defines measles elimination as the absence of measles virus transmission in a specified geographical area for greater than 1 year in the presence of a successful viral surveillance campaign.[10] The current measles outbreak has provoked many thoughtful opinion pieces in the media and has provoked criticism of current American Academy of Pediatrics Association (AAP) guidelines for vaccination.[8] It has also led to controversy surrounding the population of parents that choose not to vaccinate their children.

Statement of the Problem

Measles is a very contagious disease with an attack rate of 90% among people without immunity.[11] In 2019, there was an outbreak of measles centered in NYC among people who had not been vaccinated for measles. There is a high proportion of ultra-Orthodox Jewish residents in the Williamsburg neighborhood of Brooklyn in NYC who have not been vaccinated, which led to very high rates of measles infections among that population.[12] The reasons for not vaccinating have not been studied but have been assumed to be based on religious exemption.[12] To prevent future measles outbreaks and serious complications from measles, discovering the specific barriers to vaccination is key. Using surveys to compare knowledge, attitudes and practices of parents from Williamsburg, Brooklyn (which had a vaccination rate of 79.5% before the most recent measles outbreak) with a cohort in close proximity, located just across the East River in the East Village Neighborhood of Manhattan (which has a vaccination rate of 91.5%), will allow the examination of how alternative lifestyles, religious beliefs and perceptions of the vaccine and measles disease may affect parents' decision to vaccinate their children or not.[2]

Hypothesis

There will be more parents who choose not to vaccinate their children in the Williamsburg neighborhood when compared to the neighborhood selected in the East Village.[2] The parents in the Williamsburg neighborhood will anticipate more side effects from the MMR vaccine if they have not seen a case of measles. However, if the parents have seen a case of measles, parents will be more likely to vaccinate their children with the MMR vaccine. This may also have to do with religious beliefs although more recently, rabbis and people of power in Orthodox Jewish communities have been promoting vaccination. However, change has been slow, as just last year, the Williamsburg neighborhood had a vaccination rate of 79.5% which is much lower that what is necessary to create herd immunity.[2]

Objectives and specific aims

The objective of this study is to determine whether there still remains a difference in the vaccination patterns between two populations in different geographical regions within NYC, and if so, to determine the reasons for them. The reason for focusing on specific geographical regions is to compare beliefs within the two groups without generalizing cultural beliefs to an entire region. In previous studies, there have been noted to be differences in vaccination rates between Williamsburg and East Village populations.[2] This study would seek to determine the reasons behind those differences.[3,12,13] The specific aims of this study are:

- To determine whether there is still a difference in vaccination rates between two study groups, children living in Williamsburg, Brooklyn, NY and children living in the East Village, Manhattan, NY.
- To determine the knowledge levels, attitudes and opinions of parents of children in two populations; one in the Williamsburg neighborhood of Brooklyn, NYC and one in the East Village neighborhood of Manhattan, NYC, on the measles virus and MMR vaccine.

- To discover whether a gap in knowledge or misinformation is associated with parents choosing not to vaccinate their children.
- To determine factors that may account for differences in vaccination rates between these two communities including religious and cultural backgrounds, knowledge, personal experiences, opinions, and sources of information on measles and the MMR vaccine used by parents within their community.
- Analyze the findings, to determine what kind of health campaign might effectively result in an increase in the rates of vaccination for children in those neighborhoods.

REVIEW OF THE LITERATURE

Overview

A review of the current literature relevant to measles, including the mode of virus transmission, epidemiology, possible complications and rates of those complications among vaccinated and unvaccinated, was performed to provide background for the proposed study.

Pathophysiology and Epidemiology of the Measles Virus

Humans are the only known host of the measles virus.[14] It is a member of the *Paramyxoviridae* family and the Morbillivirus genus. It is a pleomorphic, enveloped virus with a helical nucleocapsid and varies in diameter from one to two hundred nanometers (Figure 1A). It has a single-stranded, negative sense RNA (-), non-segmented genome.[14] The genome contains six genes that encode eight viral proteins.[14] The hemagglutinin is the viral attachment protein that binds cellular receptors and enables the virus to attach to host cells. The fusion protein allows fusion of the viral envelope with the host cell plasma membrane. The nucleocapsid consists of the RNA genome associated with the nucleoprotein (N), the phosphoprotein (P) and the viral RNA-dependent RNA polymerase, Large protein (L). The phosphoprotein facilitates RNA synthesis as part of the transcription complex and the nucleoprotein helps maintain the genome structure. In addition to the phosphoprotein, the P gene encodes two additional non-structural proteins, V and C, that suppress the host innate immune response. Once formed, nucleocapsids traffic to host cell plasma membrane “patches” where they interact with viral matrix protein that is present on the inner layer and viral fusion and hemagglutinin glycoproteins that have been inserted into the membrane. A diagram of the measles virus replication cycle synthesis is shown in Figure 1B. The measles virus is most closely related genetically to rinderpest virus which infects cattle and other animals and was eradicated in 2011. Scientists speculate that the virus evolved from when humans lived closely with cattle.[6] However, the current measles virus has no known animal reservoirs. There are 24 known genotypes and only 8 have been detected since 2009, suggesting that many are no longer circulating.

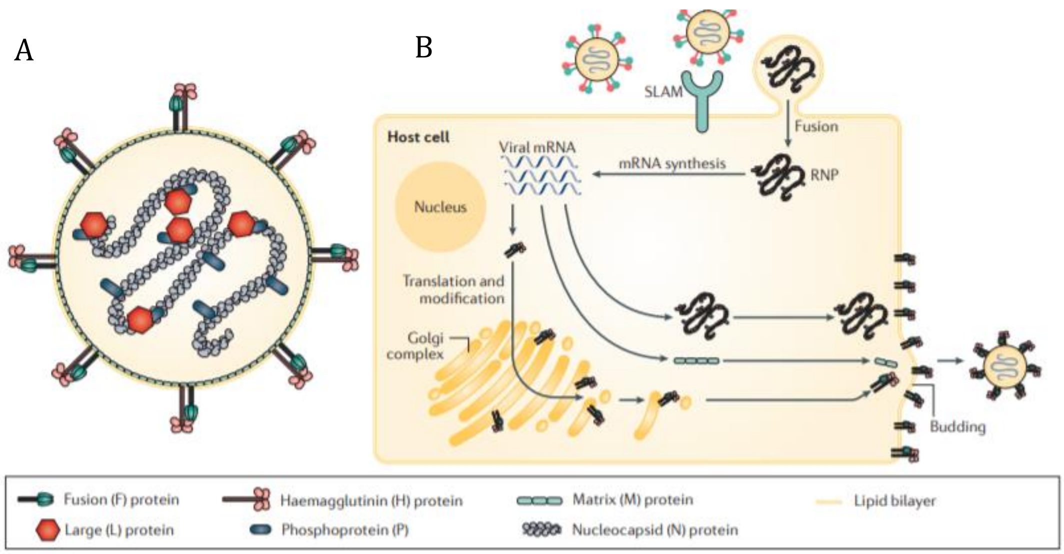


Figure 1: The measles virion (A) and viral life cycle (B). (Adapted from Rota et al. 2016) [15]

Measles has a very distinct pathophysiology. Virus is most commonly transmitted via respiratory aerosols and initially infects cells, including subsets of dendritic cells, B and T lymphocytes and macrophages, in the susceptible host via binding of the hemagglutinin to the CD150 receptor (also known as signaling lymphocyte activation molecule family 1, SLAMF1). Measles virus can also bind nectin cell adhesion molecule-4 (nectin-4) expressed by epithelial and endothelial cells, as well as keratinocytes.

Infected lymphocytes and dendritic cells disseminate the virus through the lymphatic system and are thought to “transmit” the virus to nectin-4 expressing epithelial cells through the formation of syncytia. Primary viremia occurs after virus enters the bloodstream from the lymphatic system and travels to reticuloendothelial sites where virus replication continues. Virus then enters the bloodstream again in a secondary viremia several days later and spreads to multiple other organ systems. The ability of the virus to infect many cell types, such as lymphocytes, monocytes, epithelial cells and endothelial cells, is likely responsible for the various presentations and symptoms of the disease, including serious complications, e.g. CNS disease, immunosuppression, and pneumonia.

Measles has an incubation period of ten to twelve days. On average, it takes about fourteen days from initial exposure to the virus before a rash develops (range 7-21 days).[1] However, patients are infectious before they develop any rash or symptoms, which contributes to the danger of the measles virus. Infectivity is highest in the prodromal phase, from four days before the rash develops to four days after the rash develops when viral levels are the highest within the respiratory tract. During this time, replication of the virus in the respiratory tract causes coughing and sneezing, resulting in production of highly infectious aerosols.

Some of the adverse events associated with measles are due to the host immune response to the viral infection. Contact with the measles virus triggers both cellular and humoral immune responses. The cellular response is necessary for clearance of virus-infected cells and recovery with severe and potentially fatal complications of the disease developing more frequently in those having T-cell deficiencies, such as AIDS.[14] The humoral response is responsible for the long-term immunity to re-infection. IgM antibodies arise at the time of rash onset and last for 6-8 weeks.[6] Identification of IgM measles antibody in serum is the basis of the immunoassay to diagnose current or recent measles virus infection. Subsequently, isotype-switching leads to production of measles virus-specific IgG in the blood and IgA at mucosal membranes that neutralize virus by binding to the viral hemagglutinin. Detection of IgG measles antibody in patient serum indicates measles immunity due to vaccination or previous exposure.

Acute infection with measles virus is associated with a transient immunosuppression, making the host susceptible to other infections or reactivation of persistent infections, e.g. herpesviruses. The mechanism of this phenomenon is not clearly understood but is thought to be due to viral replication in lymphoid tissues leading to both qualitative and quantitative effects on immune cells and/or function. However, immunosuppression is short-lived and long-lasting protective immunity is established with resolution of the infection.

Measles Infection

Measles is a difficult disease to recognize in the early stages. Thus, it can be disseminated to an under-immunized or otherwise non-immune community long before symptoms appear or the disease can be diagnosed. The most common measles symptoms are oral lesions, rash, fever above 38.3°C (101°F), cough, coryza, conjunctivitis, photophobia from iridocyclitis, and mild to moderate GI symptoms.[16] Infants that are not yet immunized against measles are the most susceptible to measles infection. In one outbreak, 44% of measles cases were in children <15 months of age who had not yet been eligible for vaccination.[16] Without antibodies to the disease, for every ten people exposed to the virus, nine will become infected.[11]

Koplik's spots are white papules on an erythematous base on the buccal mucosa and are pathognomonic for measles infection (Figure 2). These spots are significant because they are the earliest sign of measles infection and an indication that the person is infectious. The spots appear one day prior to the rash in 60-70% of patients that eventually develop measles.[16]

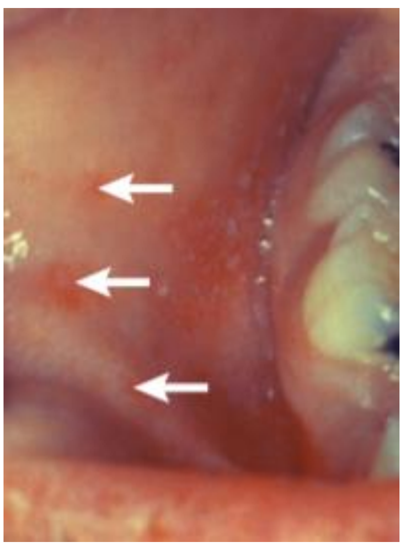


Figure 2: Koplik's Spots (Adapted from Rota et al, 2016)[15] The earliest evidence of measles infection.

The rash associated with measles infection presents as erythematous macular or maculopapular lesions that may coalesce, and start behind the ears and on the hairline, then spread from the face down to the feet over a period of three to four days (Figure 3).[17] The rash also clears over 3-4 days from the face to the feet.

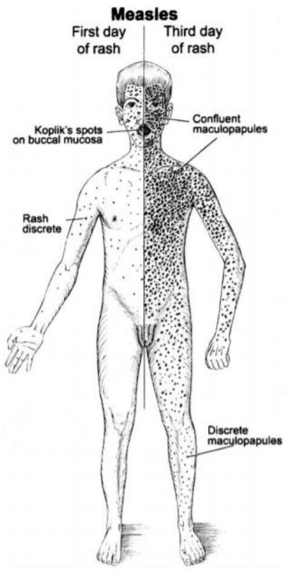


Figure 3: Rash of the Measles Virus. (Adapted from Perry and Halsey, 2004)[18]

Other early symptoms, including high fever, cough, conjunctivitis, photophobia and GI symptoms, are also commonly seen in other infections, making it difficult to distinguish measles at this stage. Diarrhea associated with measles only occurs in 8% of cases but is more likely in those less than 5 years old or over 30 years old. It typically begins before rash onset but the bacterial makeup of stool is the same whether the patient has measles infection or not. In addition, since measles virus does not survive in the GI tract, there is currently no diagnostic test for measles using stool specimens. This is an important complication in developing countries because, before availability of the measles vaccine, 77% of all diarrheal deaths in developing countries were associated with measles.[18] In a study of measles in California, 32% of patients hospitalized with measles were dehydrated, suggesting that fluid loss could be a major contributing factor to the development of more severe symptoms from measles infection.[18] In studies from other resource poor communities, a link between measles and diarrhea was shown.

There are several possible complications associated with measles. These include acute disseminated encephalomyelitis (ADEM), measles inclusion body encephalitis (MIBE), subacute sclerosing panencephalitis (SSPE), laryngotracheobronchitis, otitis media and pneumonia. Although these complications vary in frequency of occurrence – some, e.g. pneumonia, are more common than others, e.g. SSPE - some can lead to death. Complications occur in up to 35% of patients infected with measles and are more common in patients who get infected under the age of 5 or older than 30 (Table 1). [14,16]

Table 1. Complications of measles in the United States, 1987-2000[18]

Complication	Overall (67,032 cases with age information)	No. (%) of persons with complication, by age group				
		<5 years (n = 28,730)	5–9 years (n = 6492)	10–19 years (n = 18,580)	20–29 years (n = 9161)	>30 years (n = 4069)
Any	19,480 (29.1)	11,883 (41.4)	1173 (18.1)	2369 (12.8)	2656 (29.0)	1399 (34.4)
Death	177 (0.3)	97 (0.3)	9 (0.1)	18 (0.1)	26 (0.3)	27 (0.7)
Diarrhea	5482 (8.2)	3294 (11.5)	408 (6.3)	627 (3.4)	767 (8.4)	386 (9.5)
Encephalitis	97 (0.1)	43 (0.2)	9 (0.1)	13 (0.1)	21 (0.2)	11 (0.3)
Hospitalization	12,876 (19.2)	7470 (26.0)	612 (9.4)	1612 (8.7)	2075 (22.7)	1107 (27.2)
Otitis media	4879 (7.3)	4009 (14.0)	305 (4.7)	338 (1.8)	157 (1.7)	70 (1.7)
Pneumonia	3959 (5.9)	2480 (8.6)	183 (2.8)	363 (2.0)	554 (6.1)	379 (9.3)

Source: Centers for Disease Control and Prevention.

Acute disseminated encephalomyelitis (ADEM) involves autoimmune-mediated destruction of myelin. This can be caused by many viruses, including influenza, measles, mumps, rubella, varicella-zoster virus, cytomegalovirus and herpes simplex virus. This complication occurs in as many as 3/1000 cases of measles.[17,18] ADEM typically occurs three to ten days after rash onset. It is thought to be caused by an abnormal immune response that develops in response to measles virus and cross-reacts against myelin basic protein.[18] Higher rates of ADEM have been found in patients who become infected with measles virus as adults and adolescents compared to younger children.[18] In ADEM, patients will present one week to one month after a viral infection with new fever, altered mental status and other multifocal neurological deficits. The virus is rarely detected in the cerebrospinal fluid of ADEM patients, likely because the disease is diagnosed after the immune response has cleared the virus and is the result of an adaptive response to both the virus and host myelin basic protein[18] Approximately 25% of patients diagnosed with ADEM die from it.[18] Many (33%) have lifelong consequences of ADEM from measles, including include major neurological problems, deafness, blindness, motor impairment and hemiparesis.[18]

Measles inclusion body encephalitis (MIBE) is a progressive measles infection of the brain that causes neurological deterioration and death in patients with impaired cellular immunity. It has been documented in patients who are immunosuppressed following organ transplant or are HIV positive.[6] It occurs five weeks to six months after measles infection and is characterized by mental status changes and seizures. Death occurs within weeks of symptom presentation.[18]

Subacute sclerosing panencephalitis (SSPE) is a delayed complication of measles due to the persistence of defective measles virus in the brain as a “slow” virus infection that occurs in 1/10000 cases.[6] It occurs 5-10 years after measles infection, typically in patients that had measles before 2 years of age. Rates of SSPE have been found to be as high as 1/609 cases in patients who had measles before one year of age. The spectrum of SSPE symptoms include seizures, progressive deterioration of cognitive and motor function and in most cases, death.[11]

Otitis media is the most common complication of measles.[18] It occurs in 14% of children less than 5 years old with the rate decreasing with increasing age. It is likely a function of the Eustachian tube diameter increasing with age, decreasing susceptibility for this complication.[18] Otitis media occurs when inflammation of the epithelial surface of the Eustachian tube causes obstruction and subsequent bacterial infection.

Laryngotracheobronchitis, or “measles croup,” is observed in 9-32% of US children hospitalized with measles, the majority of whom are less than two years old. In half of the cases, cultures of tracheal samples indicate secondary bacterial infection causing either tracheitis or pneumonia. This is due to the immunosuppression caused by the measles virus, which induces cellular and humoral immune responses that are then altered during infection by an unknown mechanism resulting in compromised function for several weeks to several years after infection.[19] The most commonly isolated organisms responsible for pneumonia are *Staphylococcus aureus* or *Streptococcus pneumoniae*. It is the second most common cause of death worldwide of children who are infected with measles.[18]

Pneumonia is the most common complication of measles causing death in children in the U.S.[14,18] Pneumonia is responsible for 60% of measles-related deaths.[18] In studies of children hospitalized with measles, 55% had radiographic changes of bronchopneumonia, consolidation or other infiltrates. Among children with severe disease, 77% of had radiographic changes on chest x-ray (CXR), whereas only 41% of children with mild disease had radiographic changes on CXR. The causes of pneumonia in measles-infected children are secondary infection with another virus (herpes simplex virus or adenovirus), secondary bacterial infection, or measles virus alone. The pneumonia typically develops two weeks after the onset of symptoms of measles.

Measles can also cause Hecht's giant cell pneumonia, which is more commonly found in immunocompromised patients but can occur in immunocompetent adults and children.[11]

Immunocompromised patients are more likely to have severe complications associated with measles infection, in general, when compared to patients with normally functioning immune systems.[18] They also tend to have more severe manifestations of the common symptoms of measles and a higher incidence of secondary complications. Greater than 40% of immunocompromised patients have complications of measles infection when compared to 10-40% of patients who have normally functioning immune systems. The most common complications in this population are pneumonitis (58%) and encephalitis (20%).[18] Pneumonitis is inflammation of lung tissue, which occurs without the presence of an infectious cause, after measles infection. The fatality rate of immunocompromised patients with complications after measles infection is 55%.[14] Immunocompromised individuals can have unprovoked reappearance of rash and pneumonitis in intervals over their lifetime.[18] In a review of 40 cases of children with malignancies causing immunosuppression who were also infected with the measles virus, 58% had pneumonitis (compared to 5.9% in normal healthy children[18]), 20% had encephalitis (compared to 0.1% in normal healthy children[14]) and 8% had both.[18] Following a bone marrow transplant, a measles infection can develop again even if both the donor and the recipient have previously been vaccinated or infected.[18] Children born to untreated HIV-infected mothers become susceptible to measles (and other infections) at an earlier age than children born to healthy mothers, presumably due to the transfer of reduced levels of maternal antibodies resulting from decreased B cell function.[18] HIV-infected children mount a less robust immune response to the measles virus and the vaccine, making them more susceptible to infection by the virus.[18]

There are many prognostic factors for the development of complications among those contracting measles. Measles complications are equally likely in both men and women.[14,18] However, pregnant women have the highest risk of complications from measles, including pre-term delivery, fetal death and maternal death.[18] Complication rates are highest in children less than 5 years old.[14,18] Transfer of antibodies from breastfeeding is more effective than placental transfer because breastmilk contains more immunoglobulin than infant blood.[14] Thus, as long as an infant is breastfeeding and the mother has antibodies to the measles virus, the infant should have passive immunity.[14] The second highest rates of complications are in older adults, which is thought to be due to waning immunity in older age.

Patients who are malnourished have higher case fatality rates than their well-nourished counterparts. This is due, in part, to immune system dysfunction caused by starvation. Starvation causes prolonged measles virus infection and shedding, suggesting a higher viral load and longer disease course, as well as delayed or less than full recovery. Additionally, measles also contributes to the development of malnutrition by inducing protein-losing enteropathy, increasing metabolic demands and decreasing appetite. Furthermore, children who are infected with the measles virus early in life have lower body weights when compared to uninfected children of the same age. Children with vitamin A deficiency in developing countries have increased case fatality rates when compared to children without vitamin A deficiency. [14]

Socioeconomic burden of measles

Case fatality rates in patients with measles typically declines with increased economic development.[18] Specific environmental factors that decrease measles spread include higher vaccination rates, decreased crowding, older age at infection, improved nutrition, better overall health and access to healthcare, and available and adequate treatment for complications, e.g. secondary pneumonia. Mortality associated with measles in the U.S. has declined from 25/1000 in 1912 to 1/1000 in 1962. From the 1990s-2010s, the mortality associated with measles increased to 3/1000. This increase has been attributed to more complete reporting of measles as a cause of death, higher rates of HIV and HIV reporting, higher proportion of measles infections among preschool aged children and adults, and anti-vaccination campaigns with an increase in number of people refusing to vaccinate.[18]

In developing countries, measles is a leading cause of death and disability-adjusted life-years lost.[18] In studies of developing countries in the 1970s and 80s, the case fatality rates ranged between 3% and 34%. In 2000, the WHO estimated that 30-40 million people worldwide had measles with 777,000 deaths, mostly in sub-Saharan Africa. Deaths due to measles in younger age groups in resource-poor countries are due to crowding, vitamin A deficiency (use of therapy has decreased mortality from measles), lack of access to medical care, and malnutrition.[18] This is best illustrated by increases in measles rates during times of war or famine. In Ethiopia in 2000, measles was responsible for 22% of deaths in children under 5 and 17% of deaths in children from 5-

14.[11] Specifically, in developing countries with high rates of administration of the MMR vaccine, measles mortality has approached zero.[18]

The most recent measles outbreak in New York City from 2018-2019 cost the New York Department of Health and Mental Hygiene 8.4 million dollars.[2] This was not including any costs of hospitalization or work hours lost during this time so it is likely an underrepresentation.[2] Mayor DeBlasio has estimated the recent coronavirus pandemic (COVID-19) which began in 2019, will end up costing NYC over 10 billion dollars.[20] These estimates suggest that NYC will have even more limited resources to address any additional outbreaks, e.g. measles, influenza. Thus, determining how to develop effective strategies to maximize vaccination rates for vaccine-preventable diseases will be of utmost importance.

Measles in the vaccination era

Before vaccines were available, measles, mumps and rubella were common childhood diseases and were associated with significant morbidity and mortality. Prior to the development of a vaccine in the 1960s, measles occurred in epidemic cycles worldwide (Figure 4). At that time, globally, most people were exposed to and acquired measles before adulthood (3-4 million every year)[11]. Before the vaccine, among 500,000 people who were clinically diagnosed with measles, 0.1% died, 9.6% were hospitalized and 0.2% had permanent brain damage from measles encephalitis. Since the MMR vaccination campaign was implemented, there have been a median number 63 measles cases per year (range: 37-220) from 2001-2011, much decreased from the pre-MMR vaccine era.[1]

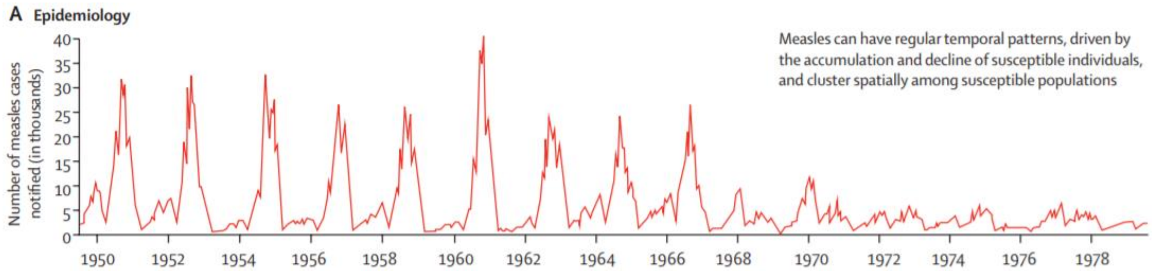


Figure 4: Epidemiology of Measles (Adapted from Moss, 2017) [11]

The measles vaccine became available in 1963 and was administered as a single dose until 1989. Measles outbreaks among vaccinated school children prompted a recommendation that children receive two doses. The second dose was administered to induce seroconversion in the small percentage of patients who experienced primary vaccine failure. It was a monovalent vaccine until the MMR vaccine was licensed to be administered to patients by Merck in 1971. Since the first measles virus vaccine and now in the MMR era, measles outbreaks have become uncommon among populations that have received 2 doses of the vaccine.[1]

In 1989, two doses of the MMR vaccine became the standard for all children. From 1989-1991, there were several measles outbreaks resulting in 55,000 cases in the U.S. and 120 directly related deaths, likely due to cases among unvaccinated urban school children.[2] To prevent this from happening again, in 1993, the Vaccines for Children program was initiated. It is a federally-funded program that provides vaccinations at no cost to eligible people under age 19. By 1995, there were only 305 reported measles cases.[1]

The MMR vaccine is a live, attenuated vaccine that could potentially eradicate the disease from the world.[16] It protects 90% of recipients from the disease and 93% of the population must be vaccinated in order to achieve herd immunity and prevent the endemic transmission of the measles virus.[1,18] In addition, exposure to infected persons can boost antibody levels in those that have been vaccinated. Adverse effects associated with the MMR vaccine are rare but include fever, rash, lymphadenopathy, joint manifestations, thrombocytopenia, or febrile seizures. In one batch of the inactivated measles vaccine, the virus was not totally inactivated by formalin and it caused persistent/atypical measles infection in the population that received it from 1963-1968.[18]

There are two vaccines for measles, the MMR, and one which also includes a varicella zoster virus vaccine (MMRV). The latter is not indicated for the first dose as it puts a child at increased risk for febrile seizures when compared to the standard MMR. Indications for the MMR vaccine are a healthy 12-15 month aged child without allergies or previous adverse reactions to vaccines. Contraindications include: history of an anaphylactic reaction to neomycin, allergy to any component of the vaccine, pregnancy, or immunosuppression of any kind.[1] Typically, reactions to previous neomycin exposures will arise as a dermatitis rather than anaphylaxis and dermatitis is not a contraindication to receiving the measles vaccine. People who have contraindications for the MMR virus are indicated to receive measles virus-specific IgG following any exposure to the virus.[1] The MMRV should be given three months from the first MMR administration. The second dose of the MMR is typically given to children aged 4-6 years right before they enter school, but should not be given sooner than 28 days from the first dose.[1] Typically, one dose results in immunity in 90% of the population. A second dose, however, boosts immunity for anyone whose antibody titers may be less than necessary for protection and can seroconvert patients who have not yet seroconverted.

Existing Literature

Opposition to Vaccination and the MMR Vaccine

In 1998, a paper published in the Lancet by Wakefield, et al. asserted that the MMR vaccine was associated with onset of bowel inflammation and regressive autism in 8 of the 12 children in the study, which was called enterocolitis/disintegrative disorder.[21] After a long and thorough investigation, the study was found to be fraudulent and unethical in numerous ways. Andrew Wakefield, the lead author, did not divulge that the study was commissioned and funded for planned litigation and that he was paid by a personal injury lawyer.[19] The subjects for the study were not recruited without bias and there were no controls. In addition, the medical histories, diagnoses, and the timeline of the development of symptoms of the proposed disorder were misreported or altered for most of the patients. The paper was officially retracted in 2010 and Andrew Wakefield's medical license was revoked. Although 10 of the 12 authors retracted their involvement with the work, Andrew Wakefield did not and remains a very outspoken advocate and a leader of the anti-vaccination movement.[22] In 2014, the journal Vaccine published a meta-analysis of over 1.2 million children that refuted the claim that vaccines cause autism.[19,23] They concluded that the close temporal relation between receiving the MMR vaccine in early childhood and a diagnosis of autism was most likely co-incident, rather than a cause and effect.[21] Numerous additional studies have been performed with none finding evidence that vaccines or any of their individual components cause autism.[21]

Despite the findings from scientifically sound studies, the Wakefield paper created profound doubt regarding the MMR vaccine and sowed public distrust of the scientific community among some people.[24] This caused MMR vaccination rates to fall as low as 79% in 2003.[24] This distrust has fueled anti-vaccination campaigns and led to the formations of “anti-vaxxer” and vaccine hesitancy groups who continue to spread misinformation in opposition to vaccinations and vaccination requirements. This is particularly problematic for public health when these people are people of power or influence in the society, such as celebrities.[25]

In addition to these misinformation campaigns, many parents have not had personal experiences with measles or the serious complications of measles virus infections in many years or in their lifetime and see this as a reason not to vaccinate their children. [26] In contrast, with an increase in the diagnosis of autism among children, many parents are well aware of this syndrome and many have children with this diagnosis. This may make them much more concerned with preventing autism than measles. As reported by Cacciatore et al., very few studies have sought to find a link between attitudes regarding vaccination and outbreaks of diseases.[4] However, many studies have sought to examine what attitudes develop after people have survived an outbreak. [24,26] The ability to determine attitudes and practices prior to an outbreak could change the course and severity of the outbreak of measles because adequate vaccination rates can prevent future outbreaks. The proposed study within this thesis seeks to determine those attitudes and how best to combat them, in order to increase vaccination rates. In order to do this, it is important to first identify the barriers to MMR vaccination.

McHale et al. conducted a study in the UK which determined the top four reasons for parents not vaccinating children with the MMR vaccine. They distributed a questionnaire to parents (N=47) who had and those who had not vaccinated their children and who's children were confirmed to have the measles virus in the most recent outbreak. Vaccine safety (28/47), child illness at time of vaccination (11/47), healthcare and individual factors (5/47) impacted parents decision whether or not to vaccinate their children.[24] This paper was published in 2016 and many participants cited a link to autism (23/47) as a concern with this vaccine, even though there is no scientific evidence for this association.[24] Safety concerns were listed as an important reason for not vaccinating. Specifically, thimerosal, a mercury containing preservative in some vaccines, has been a focus of scrutiny for fear of associated neurological side effects.[22] In 1999, the U.S. transitioned to using thimerosal-free vaccines with the exception of some flu vaccines.[21]

This study included an optional question at the end of the questionnaire asking parents whose children had gotten measles if they had any advice to give to parents who had not vaccinated their children. Nearly half (22/47) of parents said that they would recommend the MMR vaccination to those parents.[24] The parents were also keen to recommend that the dangers of measles should be more widely publicized and that they had previously had a lack of knowledge of the severity of measles infection.[24]

Parental concerns focused on the large number of vaccinations that children are given throughout the first two years of life, as recommended by the American Academy of Pediatrics. Trends have shown that as vaccination schedules become more complex, compliance with them decreases. [21] Many parents are concerned that too many vaccinations at one visit could “overwhelm” the immune system.[21] The AAP has worked to counter these misconceptions by developing numerous strategies for alleviating vaccine hesitancy in primary care pediatrician visits, as this is the primary source of information for most parents regarding their children’s health.[27] Defending and explaining the AAP vaccination recommendations in pediatrics offices has been the most effective approach in countering vaccine hesitancy among parents. Vaccines are tested thoroughly before being administered to children and are actively monitored and tested after approval.[27] These vaccines and the vaccine schedule has been tested and approved by the AAP; there are no alternative vaccine schedules at this time.[27] The perception of risks associated with vaccines has been inflamed, projected, and inflated by media scrutiny and celebrity influencers who use their platforms to spread their thoughts on vaccination, whether or not they are backed by any scientific evidence.[25]

An article by McLaren et al., explored the decreasing vaccination rates in pregnant women and reasons for these by asking women at their prenatal obstetrician visits why they had not been vaccinated.[25] The primary reasons behind decreasing vaccination rates they have found were an increasing spread of misinformation and fear, including specific fears of anti-Semitism in the Jewish community.[12,25] McLaren et al. proposed that the health belief model can be used to determine why people are not receiving available medical treatment. The first part of the model assumes that in order for people to initiate health concerns, the general population must believe it is at risk of developing an illness. Because measles is so rare in the U.S., many people making the choice as to whether to vaccinate their children have never had any experience with measles. This is important because, if the population does not feel their children are at risk, they may be more likely to not vaccinate their children, since there are risks with vaccination as well.[25] Compounding this issue, influential people within the community and celebrities have spread misinformation and propaganda that the risk and consequences of contracting measles are minor.[25] This false information being perpetuated by leaders and celebrities in many communities may be difficult to negate.[25]

McLaren et al. also discussed the importance of preventing prejudice against certain groups that have previously had lower levels of vaccination, like Orthodox Jewish communities.[25] On one occasion, a Yeshiva's preschool program was closed for failing to provide documentation of immunization leading to feelings of prejudice and further distrust in the government.[25] More recently, rabbis and faith leaders have worked closely with government officials to encourage their communities to get vaccinated in an effort to reverse many beliefs based on misinformation from the past decade, however, many parishioners are slow to change their mind and practices around vaccination.[12]

Religious objection has been grounds for not vaccinating children in the past.[21] More recently, it has been debated for the HPV vaccine, but in the past it has been used for many different vaccines.[21] Grabenstein et al. published a paper in 2013 describing what various religions teach regarding vaccinations. They discuss that Maimonides wrote, "One must avoid those things that have a deleterious effect on the body, and accustom oneself to things which heal and fortify it."[28] Jewish scholars have rejected any arguments that medical interventions interfere with any religious decree.[28] There is no religious-based belief or mandate in Judaism prohibiting vaccination, suggesting that under-vaccination in some orthodox Jewish communities is based on personal preferences.[28] In fact, in the smallpox era, scholars used the phrasing, "that counsel [should] not stand idly by while a neighbor is in trouble."[28] In more recent times, scholars have discussed a part of the Talmud indicating a necessity to teach children to swim only to prevent them from drowning. Scholars have used this as a metaphor for vaccination, suggesting that to prevent death, everything should be done to preserve human life.[28] Leaders in the Orthodox Jewish Community have also used a verse from Deuteronomy, suggesting that a person should build a railing around ones roof so as to prevent people from falling. This has been seen as a metaphor for vaccination as preventing harm to others.[28]

One reason for low vaccination rates among Orthodox Jewish communities could be due to distrust in the government requirements for vaccination and general aversion towards all vaccinations.[12] This could be because of previous prejudices they experienced including fear of anti-Semitic leaders and persecution causing distrust in all modern medicine. Another possible explanation is a religion-associated belief in fatalism, which leaves illness only within the control of God.[12] Although research by Silverberg et al. has sought to discover why Orthodox Jewish mothers choose not to vaccinate their children, she found that many within the community regarded the vaccination process with animosity and suspicion. [12,28] Silverberg et al. surveyed only five Orthodox Jewish mothers but there is a much larger population that may be willing to explain their reasoning for not vaccinating. They concluded that members of power within the community including religious leaders, healthcare providers and mothers with high social standing could positively influence the community to increase vaccination rate.[12]

Uncovering the potential reasons why some, and more specifically Orthodox Jewish residents may be hesitant to vaccinate, Silverberg et al. asked questions of five Williamsburg mothers to identify actual and perceived barriers to vaccination. They regarded the vaccination process with animosity and suspicion.[12] She also noted that in 62% of Orthodox Jewish households, neither parent completed high school. This could also explain a difference in vaccination rates.[12] This study is very similar to the study proposed here and could help determine the direction of future studies.

The 2018-2019 Measles Outbreak in NYC

There has been much research on recent measles outbreaks and specifically what could have prevented them. Some studies examined the role of imported cases of measles as the initiating factor in these outbreaks since the virus was declared no longer endemic in the United States in 2000.[1] Other studies focused on reasons behind declining vaccination rates, which contributes to the spread of the virus once introduced into the U.S. The current research focuses on past outbreaks and responses to those outbreaks.

The most recent outbreak in NYC was evaluated in a study published in The New England Journal of Medicine which examined under-vaccination in certain NYC zip codes as the cause of the most recent measles outbreak in New York City in 2018-2019.[2] In this article, Zucker et al. determined the zip codes with the highest rates of measles cases during the outbreak. They concluded that vaccination delays, in addition to importations of the measles virus, were responsible for the outbreak beginning in 2018 resulting from a traveler becoming infected in Israel and returning to nYc with an active case of measles.[2] The outbreak primarily affected the Orthodox Jewish Community who represented 93.4% of the total 649 cases confirmed.[2] Additionally, 72.9% of the of the population affected resided in the Williamsburg neighborhood of Brooklyn, New York, where the median age of patients was three.[2] The estimated vaccination level of Williamsburg before the spread of the measles virus domestically was 79.5% in children 12-59 months of age.[2]

In a study published in 2019 after Mayor de Blasio mandated vaccination in certain areas of NYC and Brooklyn, fining those that refused to get the vaccine, Cantor proposed that mandating vaccinations, although it may be helpful in the short term, will not increase vaccination rates in the long term.[29] She claimed that these mandates would deepen distrust in the government among people who were already hesitant.[29] Instead, she provided an example of an outreach program, which was much more costly, but might have the intended consequences of repairing trust in government and medicine, while also raising vaccination rates through education. In this model, nurses would go into the community with community leaders, meet with people in their own homes, teach them about the dangers of measles and the benefits of vaccination, and correct misinformation when they came across it. This way, parents that were not vaccinating could ask questions and have candid conversations with medical professionals and community leaders about the benefits of vaccination. Mayor de Blasio did mandate vaccination during the outbreak in 2019, however, its long-term effects on measles vaccination rates are unknown.

During 2019, the CDC reported 1282 confirmed cases of measles in the U.S. in 31 states, of which 128 required hospitalization and 61 had complications, including pneumonia and encephalitis.[30] In the outbreak in NYC from 2018-2019, there were 649 confirmed cases of measles.[2] The majority of these cases (89%) occurred among people who were not vaccinated for measles or had unknown vaccination status and ~75% of these cases were linked to two closely related outbreaks in N.Y. and NYC that began in late 2018 within close-knit Orthodox Jewish communities.[2] The first outbreak began in NYC (Williamsburg area of Brooklyn) with an imported case in a traveler returning to the U.S. from Israel. This outbreak lasted 9.5 months and transmission occurred among 702 unvaccinated members of this community.[2] The second outbreak began in NY state (Rockland County) with an imported case and similarly spread among unvaccinated members of the community for 10.5 months, resulting in 412 cases.[2] In 2019 the vaccination status of U.S. measles cases by age group was published by the CDC on October 11, 2019 (Table 2) which illustrated that pediatric cases were identified most in unvaccinated children.

Table 2. Number and vaccination status of measles cases in children by age group — US January 1– October 1, 2019. [31] Most cases in unvaccinated persons. (Adapted from Patel et al., 2019)

Age Group	Measles cases no. (%)	Vaccination status no. (%)		
		Unvaccinated	**Vaccinated**	**Unknown**
0-5 mos	43 (3)	43 (100)	0 (0)	0 (0)
6–11 mos	116 (9)	110 (95)	5 (4)	1 (1)
12–15 mos	118 (9)	106 (90)	12 (10)	0 (0)
16 mos–4 yrs	274 (22)	238 (87)	33 (12)	3 (1)
5–17 yrs	339 (27)	295 (87)	26 (8)	18 (5)
Overall	**1,249**			

In order to determine why the rates of vaccination in Williamsburg are lower than in the East Village, the proposed study will assess knowledge of measles and vaccines, as well as viewpoints regarding vaccination, among people in these communities. They will also seek to discover the knowledge base of both groups regarding the MMR vaccine and its side effects as well secondary effects and complications of the measles virus.

Participants in a study by McHale et al. were careful to point out that the dangers of measles were not evident to them.[24] Among these participants' experiences, measles was not a common childhood illness so they had a low perceived illness severity. They stated that their lack of experience in caring for someone with measles was the reason for the low illness severity perception. In a study conducted in Australia, when discussing perceived illness severity, those who chose to vaccinate had a higher perceived illness severity of measles than those who chose not to vaccinate.[26] Authors of this study at the Western Sydney University School of Medicine developed and published a study in 2017 interviewing two cohorts of parents regarding their views on vaccinating their children. The cohorts were separated by geography and were located on various coasts of New South Wales, Australia. The researchers aimed to determine the knowledge and opinions of parents on the MMR vaccine and the disease of Measles itself.[26] The study consisted of a questionnaire distributed to 201 respondents. They discovered that among parents who did not immunize their children, 64.7% perceived that the MMR vaccine was effective. Only 35.3% of non-immunizing respondents described the MMR vaccine as being safe, compared to parents who did immunize their children, of which 92.3% believe the MMR vaccine to be effective and 90.2% considered it to be safe. They also had varying perceived severity of the measles virus. On a scale of 1-10, 1 being not severe and 10 being the most severe, non-immunizers in New South Wales perceived measles severity as 4 out of 10 compared to immunizers who perceived measles severity as 8 out of 10.[26] One additional finding was that the mean parental age was younger among immunizer parents compared to the non-immunizer group. Similarly, mean household income was higher amongst the immunizer group than the non-immunizer group, suggesting there may be an association between age and household income and the decision to immunize.[26]

The conclusions of that study were that there were concerns about the safety of the MMR vaccine among the population that did not immunize their children. They also indicated that public health campaigns that increase confidence in the MMR vaccine will be beneficial for improving vaccination rates and potential development of a revolutionary vaccination campaign in the future. [26] The study proposed in this thesis will uncover specific reasons behind parents decisions not to vaccinate.

A paper by Cacciatore et al. hypothesized that an outbreak will elicit varying degrees of impetus for inspiring parents to vaccinate their children (Figure 5).[4] They found that an outbreak of a preventable disease did not push parents that did not want to vaccinate their children to do so.[4] However, parents that had a high vaccine interest as measured by the study (Figure 5), did vaccinate their children after a disease outbreak occurred.[4] The proposed study might ask specific questions to determine why some parents were so unwilling to vaccinate. It may also uncover better ways to convince unwilling vaccinators to change their mind.

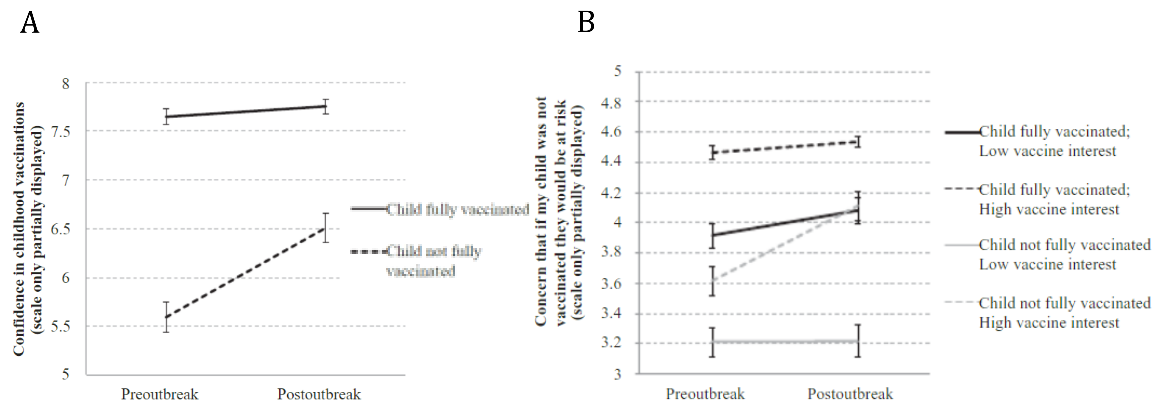


Figure 5. Vaccination Willingness Pre. Vs. Post-Outbreak A. Willingness to vaccinate children pre-measles outbreak vs. post-measles outbreak. B. Vaccine interest pre and post-outbreak. [4] **(Adapted from Cacciatore et al. 2018)**

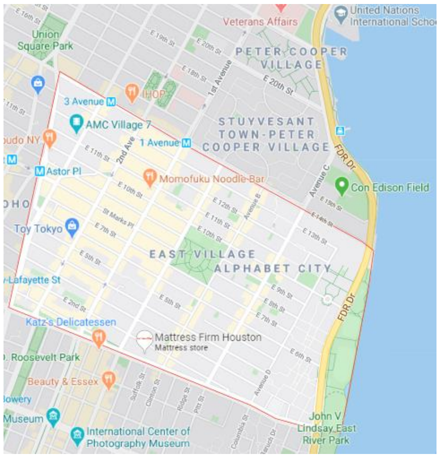
METHODS

Study design

The study will be a cross sectional study of two groups separated geographically, as well as potentially differing culturally and religiously: one population from Williamsburg, Brooklyn and one population across the East River in the East Village neighborhood of Manhattan. The study will measure the knowledge, attitudes and practices of parents regarding measles, complications of the disease and the MMR vaccine.

Study population and sampling

To be eligible for the survey, participants must have completed informed consent forms and must have been legal residents of the East Village or Williamsburg neighborhoods (Figure 5) for at least one year and have at least one child between the ages of 12 months and 12 years that are not medically exempt from receiving the MMR vaccine. One parent per family will be surveyed. The minimum number of participants total will be 350, 175 participants from each geographical location, to detect a significant difference in vaccination rates.[21] This calculation is based on estimated proportion of vaccination in the East Village of 0.972[13] and an estimated proportion of vaccination in Williamsburg of 0.80[32] with an alpha of 0.05 and a power of 0.8.[33] According to the CDC, 97.2% of children from ages 0-17 of NY are vaccinated. When the authors analyzed the most recent outbreak of measles from 2018-2019, they found that the vaccination rate of Orthodox Jewish persons in NYC prior to the outbreak was around 79.5%.[2]

A. 

B. 

Figure 6: Comparison of Two Neighborhoods, as defined by Google Maps.[34,35] A. East Village, Manhattan, NY Neighborhood. B. Williamsburg, NY Neighborhood.

Study variables and measures

The primary explanatory variable will be the geographical residence of the two different study groups and the attitudes and opinions of the study participants of their knowledge of measles and the MMR vaccine. The survey is based on the Health Belief Model and themes identified in previous research.[26] The survey will consist of 32 questions and determine on a numerical scale how knowledgeable each population is about the subject of measles and the MMR vaccine. It will also record the most common attitudes and opinions on measles and the MMR vaccine. A more detailed look at the data collected and the statistical analyses is shown in Table 3. The survey can be found in Appendix A.

Recruitment

Study participants will be recruited using flyers hung in pediatrician offices, along sidewalks, in churches and other public areas in both communities and by working with people of authority within both communities to encourage participation. Following an initial conversation including a thorough explanation of the proposed study through a primary point of contact, the participants will be contacted by phone or email. They will set up a time to complete the survey which will be administered by prominent, previously-trained, trusted members of the community. Participants' addresses will be confirmed and informed consent will be given in-person at time of recruitment or in-person during survey administration.

Data collection

Data collection will be completed by administration of surveys (Appendix A) to participants by prominent, trusted members of their respective communities. The data will be collected by filling the surveys out in person, over the phone, via e-mail or over the internet. If the surveys are to be administered in person, they can be administered in participants homes or a pediatrician's office. Addresses will be verified before survey administration to prevent duplicates. The completed surveys will be entered and compiled into an online database (Redcap) by our data entry specialist, who will be employed by the study.

Data analysis

The outcome of all the analyses that are run will strive to explain the vaccination rates. The explanatory variables will compare one population with another to determine if there is a statistically significant difference between the two groups. The vaccination rate will be analyzed using the chi-square test.

Table 3. Explanatory Variables and Planned Statistical Tests

Outcome	Explanatory Variable	Statistical Test
Vaccination Rate	Neighborhood	Chi square test
Vaccination Rate	Parental Education Level	Chi square test
Vaccination Rate	Parental Vaccination Rate	Chi square test
Vaccination Rate	Religious Preferences (Orthodox Jewish) or Other? Specify, if other?	Chi square test
Household Income	Vaccination Status	T-test
Measles Severity Index (MSI)	Vaccination Status	T-test
MMR Severity Index (MMRSI)	Vaccination Status	T-test

The Measles Severity Index (MSI) and MMR Severity Index (MMRSI) will be calculated by computing a mean based on answers to questions in the survey, which specifically ask parents to categorize how severe they believe side effects of both the measles virus and the MMR vaccine to be. Mean MSI and MMRSI will be compared between groups based on vaccination status.

Timeline and resources

IRB approval will likely take two months to obtain. Following this, the recruitment period will be for one year, or until recruitment of the minimum number of participants. Concurrently with recruitment, data collection will begin. This project will employ a statistician, four local ambassadors who will complete data collection and one person specifically responsible for data entry. A training will be held at the beginning of the study to train recruiters of study participants; this will include incentives and dinner for potential recruiters. It will also require training and paying knowledgeable and respected members of the community by the primary researcher in order to administer the survey in a methodical manner. Data analysis and manuscript preparation should take six months. Maximum time to completion of this study will be two years.

Institutional Review Board

We will submit our proposal to the IRB at BMC for human subjects research approval for Expedited Review. Our study can be expedited in that it meets criteria stating, "Research on individual or group characteristics or behavior or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies."[36]

CONCLUSION

Discussion

The proposed research project will determine the most commonly held beliefs, knowledge level, attitudes and opinions of two cohorts of parents in NYC regarding measles and vaccinations for measles. This study will allow us to see the most current differences in vaccination rates between two populations in New York. From there, answers to the survey will allow us to associate vaccination rate with other potentially explanatory variables like education level and parental vaccination history. This can allow for further explanations of potential differences in vaccination rate, including general opinions on the severity of measles and the MMR vaccine. Specifically, this study will also investigate which beliefs are strongest regarding measles and the MMR vaccine to determine what information is being received by the general public at large and within smaller, close-knit religious communities, specifically the Orthodox Jewish community in Williamsburg.

This study will be generalizable because misinformation campaigns are widely used by antivaccination strategists and combatting these will be necessary for successfully implementing vaccination campaigns. This study will be most representative of the NYC population in question because the proximity of populations with these specific cultures and beliefs are only found in this area. However, it also may be applied to other cities, like Boston for example, which has many different cultures and populations also living in close proximity to one another. The study results may also be applied to other Orthodox Jewish communities in efforts to increase vaccination rates and prevent future outbreaks.

One weakness of this study is the potential for bias. The first potential bias is selection bias, which may make it difficult to sample a true portion of the general population. The only place two populations like this are in this close proximity are New York City so it falls victim to selection bias. However, the study does have the potential for its results to be generalized to other areas where there are large Orthodox Jewish communities. The second bias this study may elicit is recall bias because, when asking respondents about their children up to age 12, they will need to recall the time when they vaccinated their children several years ago to answer some of these questions and recollections may not be accurate.

There are many potential obstacles. The first being recruiting willing adults that are located in Williamsburg. In a previous study, it was difficult finding Orthodox Jewish members of the community who were willing to talk to researchers and also were knowledgeable about their children's health records and vaccination status.[12] This could further exacerbate the selection bias.

Obtaining funding for this study should come directly through the city's emergency funding to prevent the spread of viruses in the future. Coming on the heels of the most recent coronavirus outbreak occurring in the city earlier this year, preventing an additional outbreak that can be avoided is of the utmost importance. Although this does have some differences, as the COVID-19 outbreak is not currently related to vaccination.

Summary

This study will determine whether differences in vaccination rates observed between two populations located in New York City in the past continue to persist. Furthermore, it will examine differences between the populations regarding their knowledge, attitudes and opinions about measles and the MMR vaccine. This should aid in the development of a more effective public health campaign that can be tailored to specific communities within New York state and New York City including other large populations of Orthodox Jewish practitioners. Discovering why these populations choose not to vaccinate and customizing campaigns to decrease that number will help to prevent future outbreaks of measles. Increasing the vaccination rate for all New Yorkers to decrease preventable diseases will make New York safer and decrease risks for those patients who cannot receive the vaccine.

Clinical and/or public health significance

The results of this study would allow cities, in particular, the New York Department of Public Health (NYDPH) and the Boston Public Health Commission (BPHC) to determine what information needs to be emphasized to a reluctant public to increase vaccination rates. Specifically, discovering what is preventing certain populations from vaccinating their children can help in developing education campaigns that address specific concerns and misinformation within undervaccinated communities. It could also determine what information might better convince parents to vaccinate their children schedule for all vaccine-preventable diseases. There is a critical need to develop effective strategies to increase vaccination rates, in general, and in particular for measles which has been targeted for worldwide eradication.

This is also significance in context of the recent coronavirus (COVID-19) outbreak. Once a vaccine becomes available, vaccinating as many people as possible to prevent disease spread will be of utmost importance to prevent unnecessary deaths. Discovering the best way to implement vaccination campaigns by discovering attitudes and opinions about current vaccines can allow targeted campaigns to increase vaccination rates in the future.

APPENDIX A

Participant Number ____________ Address Verification onsite (license, passport, piece of mail and ID) ☐
Relationship to child: Williamsburg, Brooklyn resident ☐
Mother ☐ DOB ____ Highest level of education completed __________ East Village, Manhattan resident ☐
Father ☐ DOB ____ Highest level of education completed __________
Household Income Yearly ______________
Number of Children Total ________
What is your religion? ☐Jewish ☐Not Jewish
If Jewish: What subtype do you identify with? ☐Reform ☐Conservative ☐Orthodox ☐Reconstructionist ☐Nondenominational

Have you been vaccinated? ☐ Yes ☐ No
If no, why? ____
Have you ever met anyone that has been vaccinated? ☐ Yes ☐ No ☐ I don't know
Have you ever met anyone that has been vaccinated with the MMR vaccine? ☐Yes ☐No ☐ I don't know
Have you ever met anyone that has not been vaccinated? ☐ Yes ☐ No ☐ I don't know
Have you ever met anyone that has not been vaccinated with the MMR vaccine? ☐ Yes ☐ No ☐ I don't know
Have you ever met anyone who has had complications associated with a vaccine? ☐ Yes ☐ No ☐ I don't know
Have you ever met anyone who has had complications associated with the MMR vaccine? ☐ Yes ☐ No ☐ I don't know
Have you ever had complications with the MMR vaccine? ☐ Yes ☐No ☐ I don't know
Have you ever met anyone that has had measles? ☐ Yes ☐ No ☐ I don't know
Have you ever had measles? ☐ Yes ☐ No ☐ I don't know
Have you ever had complications from a measles infection? ☐ Yes ☐ No ☐ I don't know
Have you ever met anyone who had complications from a measles infection? ☐Yes ☐No ☐ I don't know

On a scale of 0 – 10 with 0 being no illness/disability at all, and 10 being the worst illness/disability a person could experience…

From what you have heard, learned, experienced, or read about, how severe do you believe a measles infection is? _______
What are some of the symptoms of measles? ☐Rash ☐Fever ☐Feeling unwell ☐Cough ☐Conjunctivitis (eyes) ☐runny nose ☐Koplik's spots (mouth) ☐sore throat ☐Other: __________________________ ☐ Don't know
From what you have heard, learned, experienced, or read about, how severe do you believe any complications from contracting measles could be? _______
What are some of the complications a person could have from having the measles infection? ☐Brain inflammation ☐Death ☐Blindness ☐Pneumonia ☐Other____________ ☐Don't know
From what you have heard, learned, experienced, or read about, how severe do you believe complications from receive the MMR vaccine are? _______
What are some of the potential complications of receiving the MMR vaccine? ☐Fever ☐Rash ☐Measles (mumps or rubella) ☐Autism ☐None ☐Other _____________ ☐Don't know

On a scale of 0 – 10, with 0 being strongly disagree, 5 being neutral and 10 being strongly agree…

Measles is a highly contagious disease.: _______
Measles is a common disease found throughout the United States : _______
Measles can have lasting complications : _______
Measles can be deadly : _______
The MMR vaccine is effective at preventing the Measles illness : _______
Side effects from MMR can be serious : _______
Side effects of MMR can occur often : _______
The MMR vaccine can be deadly : _______

Child Number 1 (Age from oldest to youngest):
Age _____
Gender: ☐Male ☐ Female ☐ Non binary
Vaccination status: ☐ Fully Vaccinated ☐ Unvaccinated ☐ Partially vaccinated
If unvaccinated or partially vaccinated, why? ____
When were they vaccinated as suggested by pediatrician? ☐ On schedule ☐Not on schedule

Child Number 2 (Age from oldest to youngest):
Age _____
Gender: ☐ Male ☐ Female ☐ Non binary
Vaccination status: ☐ Fully Vaccinated ☐ Unvaccinated ☐ Partially vaccinated
If unvaccinated or partially vaccinated, why? ____
When were they vaccinated as suggested by pediatrician? ☐ On schedule ☐ Not on schedule

Child Number 3 (Age from oldest to youngest):
Age _____
Gender: ☐ Male ☐ Female ☐ Non binary
Vaccination status: ☐ Fully Vaccinated ☐ Unvaccinated ☐ Partially vaccinated
If unvaccinated or partially vaccinated, why? ____
When were they vaccinated as suggested by pediatrician? ☐ On schedule ☐ Not on schedule

Child Number 4 (Age from oldest to youngest):
Age _____
Gender: ☐ Male ☐ Female ☐ Non binary
Vaccination status: ☐ Fully Vaccinated ☐ Unvaccinated ☐ Partially vaccinated
If unvaccinated or partially vaccinated, why? ____
When were they vaccinated as suggested by pediatrician? ☐ On schedule ☐ Not on schedule

Child Number 5 (Age from oldest to youngest):
Age _____
Gender: ☐ Male ☐ Female ☐ Non binary
Vaccination status: ☐ Fully Vaccinated ☐ Unvaccinated ☐ Partially vaccinated
If unvaccinated or partially vaccinated, why? ____
When were they vaccinated as suggested by pediatrician? ☐ On schedule ☐ Not on schedule

Child Number 6 (Age from oldest to youngest):
Age _____
Gender: ☐ Male ☐ Female ☐ Non binary
Vaccination status: ☐ Fully Vaccinated ☐ Unvaccinated ☐ Partially vaccinated
If unvaccinated or partially vaccinated, why? ____
When were they vaccinated as suggested by pediatrician? ☐ On schedule ☐ Not on schedule

☐ Additional Children (use another survey sheet)

Address of participant:

LIST OF JOURNAL ABBREVIATIONS

Am J Med	American Journal of Medicine
Am J Perinatol	American Journal of Perinatology
Austr New Zealand J Public Health	Australian and New Zealand Journal of Public Health
Dtsch Arztebl Int	Deutsches Ärzteblatt International
Epidemiol Infect	Epidemiology and Infection
Hong Kong Med J Xianggang Yi Xue Za Zhi	Hong Kong Medical Journal
Ital J Pediatr	Italian Journal of Pediatrics
J Infect Dis	Journal of Infectious Diseases
JAMA Pediatr	JAMA Pediatrics
Nat Rev	Nature Reviews
N Engl J Med	New England Journal of Medicine
Pediatr Rev	Pediatrics in Review
Pharm Ther	P&T: Pharmacy and Therapeutics
Risk Anal	Risk Analysis

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