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Multilevel Factors Affecting COVID-19 Vaccination Among African American Communities in South Carolina

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MULTILEVEL FACTORS AFFECTING COVID-19 VACCINATION AMONG AFRICAN AMERICAN COMMUNITIES IN SOUTH CAROLINA

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DEDICATION

This dissertation is dedicated to my parents, Chunnuan Huang and Jingdong Zhang, and to all my family members, dear friends, and colleagues who have supported me unconditionally throughout my studies. I am also dedicating my work to all community members who continue to build confidence and pursue a better life while facing the disparities. Your belief in me and the importance of my work have made this journey worthwhile.

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ABSTRACT

Background: Persistent health disparities has led to significant public health challenges, especially for African American (AAs) communities, and have been exacerbated by the COVID-19 pandemic. Achieving high population vaccination rates are crucial to controlling the virus' spread. However, AAs have higher rates of COVID-19 infection and mortality than Whites, yet their vaccination rates remain relatively low. The dissertation aimed to investigate the multilevel factors and mechanisms that affect AAs' vaccination behavior. The first objective was to assess the impact of the intrapersonal level factor (i.e., perceived barriers to vaccination) on vaccination behavior. The second objective was to investigate the impact of the interpersonal level factor (i.e., health providers' recommendations) on vaccination behavior. The third objective was to examine the impact of the structural level factor (i.e., residential segregation) on vaccination rates' disparities between AAs and Whites.

Methods: The dissertation employed two types of data. Studies 1 and 2 utilized individual level data from a cross-sectional survey among 2,029 AAs in South Carolina (SC) conducted from November 2021 to September 2022. Variables such as demographic information, perceived barriers to vaccination, information seeking about COVID-19 vaccines, trust in public health agency, health care providers' recommendations, confidence in COVID-19 vaccines, and vaccination behavior were analyzed using descriptive statistics, correlation analysis, and structural equation modeling to investigate mediation effects. Study 3 analyzed county level data across 46 counties in SC to

examine the impact of residential segregation (e.g., an index of dissimilarity) on vaccination disparities between AAs and Whites, employing correlation and multivariate linear regression analyses.

Results: Findings revealed a complex interplay of factors at different levels. Study 1 demonstrated that perceived barriers are inversely related to confidence in COVID-19 vaccines, which is, in turn, negatively associated with vaccination behavior. AAs' confidence in COVID-19 vaccines mediated the relationship between perceived barriers and vaccination behavior. In addition, information seeking about COVID-19 vaccines moderated the relationship between perceived barriers to vaccination and confidence in COVID-19 vaccines. Study 2 showed that confidence in COVID-19 vaccines mediated the relationship between health care providers' recommendations and AAs' vaccination behavior. Trust in the public health agency moderated the relationship between health care providers' recommendations and confidence in vaccines, with higher trust levels strengthening the impact of health care providers' recommendations on confidence in vaccines. For study 3, among the 46 counties analyzed, 25 counties were identified as least segregated, and 21 counties as most segregated. Findings revealed that in the most segregated counties, AAs were fully vaccinated at a rate 9.59% lower than their White counterparts. In the least segregated counties, AAs received were fully vaccinated at a rate 9.25% higher than Whites. Higher levels of residential segregation were associated with lower vaccination rates among both AAs and Whites, and differences in vaccination rates between AAs and Whites were found to increase with greater residential segregation.

Conclusion: To enhance vaccination rates in AA communities, it is crucial to implement interventions specifically tailored to overcome the unique barriers to vaccine uptake. Health care professionals should give priority to community engagement and collaboration to facilitate the dissemination of trustworthy vaccine information, thereby boosting vaccine confidence and acceptance. In addition to emphasizing credible healthcare recommendations, there is a need to rebuild and reinforce trust in public health agencies. By adopting a dual approach that underscores both medical advisement and trust in the public health infrastructure, strategies can be more efficacious in addressing vaccine hesitancy among AAs. Furthermore, the consideration of racial residential segregation is essential in the allocation of resources for vaccination promotion. Recognizing and addressing intrapersonal, interpersonal, and structural level factors, allows for more tailored strategies that offer to the most affected communities. This targeted approach can enhance vaccination rates among AAs populations, thereby improving the overall preparedness of the health care system for future public health challenges.

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LIST OF ABBREVIATIONS

AA.....African American
CDC ..... Center for Disease Control and Prevention
CFA.....Confirmatory Factor Analysis
CFI ..... Comparative Fit Index
NASEM .....National Academies of Science, Engineering, and Medicine
RMSEA..... Root Mean Square Error of Approximation
SCCHWA .....South Carolina Community Health Worker Association
SCDHEC.....South Carolina Department of Health and Environmental Control
SD .....Standard Deviation
SEM .....Structural Equation Modeling
TLI .....Tucker-Lewis Index
WLSMV..... Weighted Least Squares Mean and Variance

CHAPTER 1

INTRODUCTION

1.1 Overview of the COVID-19 pandemic and health outcomes

The COVID-19 pandemic, caused by the novel coronavirus SARS-CoV-2, first emerged in late 2019 and swiftly evolved into a global health crisis, resulting in significant mortality and morbidity worldwide (1). As of March 2023, the United States has reported over 103 million confirmed cases and more than one million deaths, emphasizing the severity of the pandemic's impact (2). The COVID-19 symptoms vary, ranging from asymptomatic cases to severe illnesses (3). Common symptoms include cough, fever, shortness of breath, muscle aches, sore throat, fatigue, and loss of taste (3). These symptoms usually appear within two to 14 days after exposure (4). Importantly, individuals can transmit the virus to others even two days before symptoms appear, remaining contagious for 10 to 20 days based on their immune system and disease severity (4). Although many individuals experience mild symptoms and recover without specialized treatment, certain populations (e.g., the elderly, people who are immunocompromised, and people with underlying medical conditions) face a heightened risk of severe outcomes (e.g., hospitalization) (4, 5). In addition to individual health impacts, the pandemic has also strained health care systems and disrupted services, further highlighting the challenges at the community and institutional levels (6-8).

1.2 General information about COVID-19 vaccines

Urgency of COVID-19 vaccines development and implementation. Given the continuous emergence of mutations and variants of the COVID-19 virus, the development, authorization, and rapid deployment of COVID-19 vaccines has become paramount in public health strategy (9, 10). COVID-19 vaccines can not only prevent people from contracting the virus, but also mitigate the severity of symptoms and the likelihood of death following infection. The United States Centers for Disease Control and Prevention (CDC), in collaboration with the National Academies of Science, Engineering, and Medicine (NASEM), recognized the urgency and proposed a framework for administering COVID-19 vaccines, prioritizing vulnerable and high-risk populations, including those with greater exposure risks and pre-existing health conditions (11, 12).

COVID-19 vaccines development: types and approvals. Three types of COVID-19 vaccines are available in the United States, including: 1) messenger RNA (mRNA) vaccine such as Pfizer-BioNTech and Moderna; 2) vector vaccine such as Janssen from Johnson & Johnson; and 3) protein subunit vaccine such as Novavax (13, 14). During the initial phase of vaccine development, the Food and Drug Administration (FDA) granted Emergency Use Authorization (EUA) to the Pfizer-BioNTech vaccine on December 10, 2020, followed by mass vaccinations on December 14, 2020 (14, 15). Subsequent EUAs for Moderna (December 17, 2020) and Janssen vaccines (February 27, 2021) were issued (16, 17). By April 19, 2021, all the states had expanded vaccine eligibility to residents aged 16 and older (18). On May 10, 2021, the FDA approved the Pfizer-BioNTech vaccine for adolescents aged 12 to 15 (18). Later, on August 23, 2021, the FDA granted

full approval to the Pfizer-BioNTech vaccine for individuals aged 16 and older (Table 1.1) (18).

Table 1.1 Timeline of vaccine development and approval

Vaccine	Submitted Emergency Use Authorization	Emergency Use Authorization	Deployment	Full Approval
Pfizer-BioNTech	✓ November 20, 2020	✓ December 11, 2020	✓ December 14, 2020	✓ August 23, 2021
Moderna	✓ November 30, 2020	✓ December 17, 2020	✓ December 21, 2020	✓ January 31, 2022
Janssen	✓ February 4, 2021	✓ February 27, 2021	✓ March 1, 2021	✗ No
Novavax	✓ January 31, 2022	✓ July 19, 2022 (ages 18+)	✓ August 1, 2022	✗ No

Access and allocation strategies. Given the prolonged timeline traditionally associated with vaccine development and the urgency necessitated by the pandemic, the development and distribution of vaccines faced significant challenges (19). As the United States continues to fight against COVID-19, the newly launched vaccines have raised many questions about the equitable allocation and accessibility. With resource constraints at the outbreak of the pandemic, public health authorities and immunization programs had to prioritize certain groups for early vaccine access, specifically those for whom vaccination would prevent high rates of transmission, severe illness, or death, thereby maintaining the functioning of essential services and health care systems. Drawing on comprehensive evidence that considers various geographical and social contexts, the World Health Organization's (WHO) Strategic Advisory Group of Experts on Immunization has determined priority categories: 1) frontline workers in health and

social care settings, 2) people over the age of 65, and 3) people under the age of 65 who have underlying health conditions that put them at a higher risk of death (20, 21).

Safety of COVID-19 vaccines. As of April 2023, approximately 81.3% of the United States population had received at least one dose of COVID-19 vaccines, which significantly demonstrates the broad coverage of the vaccination program (22). All approved COVID-19 vaccines have received rigorous testing prior to launch and continue to be monitored after launch to ensure that their protective effects in all populations continue to be validated (23). These vaccines have been evaluated in large-scale randomized controlled trials, ensuring their efficacy and safety across all demographics, including a broad age range, all genders, different ethnicities, and people with pre-existing medical conditions (24). Specifically, the vaccines have also demonstrated safety and efficacy in people with underlying conditions that increase the risk of severe COVID-19, such as hypertension, diabetes, and stable controlled chronic infections. For special groups such as people with compromised immune systems, older adults with severe frailty, people with a history of severe allergic reaction to vaccines, and people living with HIV, are advised to seek medical consultation prior to vaccination (24).

Vaccine side effects and public perceptions. Side effects following vaccination may affect people's daily activities, and most people may experience mild-to-moderate side effects (25). Commonly reported side effects include fever, fatigue, headache, muscle pain, chills, and diarrhea. These usually occur within one to two days after vaccination and resolve on their own within a few days. These reactions are normal signs that the body is building protection (25-27). In addition, there are some rarer adverse effects associated with mRNA vaccines, such as myocarditis, glomerular diseases, and

cutaneous eruptions (26). Although these conditions are less common, they are also reasons for people's hesitancy towards vaccination.

Vaccine efficacy, effectiveness, and protection. All COVID-19 vaccines approved for emergency use by the WHO have been through randomized clinical trials to access their quality, safety, and efficacy. Vaccine efficacy refers to the ability of a vaccine to reduce the risk of COVID-19 infection under controlled trial conditions, thus providing a reliable benchmark for its protective potential (24). Once used in a broader population, measures of effectiveness become applicable, reflecting how a vaccine performs under real-world conditions and its impact on public health outcomes. Effectiveness captures the role of vaccines in preventing transmission, reducing disease severity, and lowering hospitalization rates in vaccinated populations. For a vaccine to provide maximum protection, the entire vaccination process must be completed, as this allows the immune system to build strong defenses against the virus. (28, 29).

1.3 COVID-19 key transmission periods and gaps in COVID-19 vaccination rates

The United States has experienced five waves of the COVID-19 pandemic since 2020 (30), with each wave revealing critical insights into the virus transmission dynamics and the vital role of vaccination efforts. The initial wave in the spring of 2020, while geographically concentrated, had profound implications for national preparedness and highlighted disparities in testing availability, leading to a substantial underestimation of cases (30). Regions such as New York City and New Orleans became early epicenters, dealing with resource allocation and health care capacity challenges (30). Subsequent peaks, including the summer wave of 2020, saw widespread increases in cases and deaths, with states like South Carolina, Alabama, and Georgia setting distressing new

records (30). This period coincided with a lag in the establishment of comprehensive vaccination programs, exacerbating the pandemic's significant impact.

With the advent of vaccination programs, the early spring 2021 wave, propelled by the Alpha variant, presented an association of heightened transmissibility with growing vaccination efforts. As vaccination rates accelerated, a record number of doses were administered daily, signaling the beginning of a large-scale counteroffensive against the COVID-19 pandemic (31). The Delta and Omicron variants, which emerged in the summer of 2021 and late 2021 respectively, posed new challenges to control the pandemic (32). Delta's enhanced infection significantly increased transmission rates, while Omicron's extraordinary spread marked it as one of the most transmissible viruses in history (32). However, the mitigated severity of illness due to the Omicron variant, coupled with the cumulative immunity from vaccinations, resulted in a relatively lower proportion of cases leading to hospitalization or death (Figure 1.1) (31).

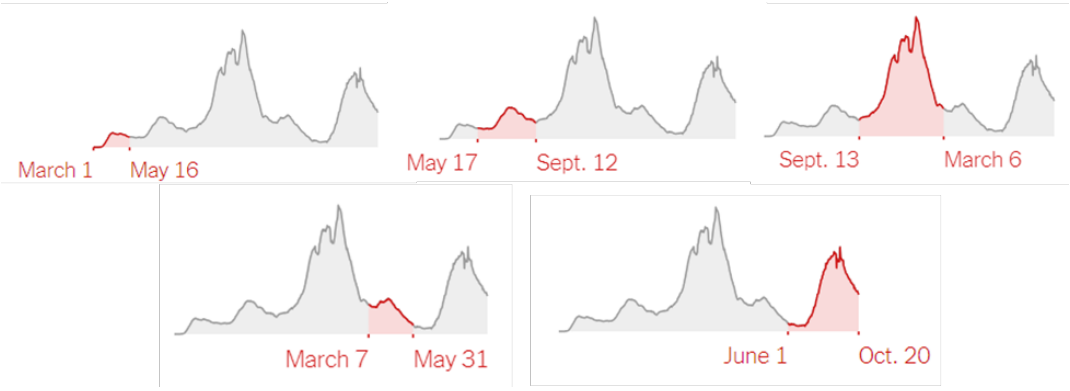

Figure 1.1 COVID-19 waves between March 1, 2020 and October 20, 2021

However, the impact of the pandemic has been uneven across different populations, disproportionately affecting underserved communities (33, 34). African Americans (AAs) has experienced a disproportionate burden, with higher rates of COVID-19 infection and adverse health outcomes rooted in structural racism and

disparities in socioeconomic status, access to health care, and occupation exposure risks (35, 36). Studies showed that, compared to Whites, AAs experienced a 2.6 times higher rate of testing positive for COVID-19, a 4.7 times higher rate of hospitalization, and a 2.1 times higher mortality rate (37). This disparity extended to vaccination rates. In the early vaccination phase (January 2021), only 48% of AA adults were willing to be vaccinated immediately, compared to 60% of White adults (38). Between January and March 2021, a vaccination rate disparity was apparent, with 54.8% of Whites having received the vaccine compared to only 32.% of AAs (37). In response to these vaccination disparities, targeted outreach and vaccination promotion interventions were implemented, aimed specifically at reducing vaccine hesitancy among AAs communities (39). By May 2021, AA adults having received at least one dose of COVID-19 vaccines rose to 56% (38, 40). Although the improvements in vaccination rates among AA communities, the persistent difference in vaccination rates compared to White populations remains a clear indicator of the ongoing challenges in achieving equitable public health outcomes. This gap in COVID-19 vaccination rate indicates a risk of continuing and potentially exacerbating health disparities among vulnerable groups (41).

1.4 Health disparities in COVID-19 vaccination between AAs and Whites

The COVID-19 pandemic has exacerbated pre-exiting health disparities across racial and ethnic groups, highlighting systemic inequities in access to health care services, quality of care, and treatment outcomes. By comparing the vaccination rates among different racial and ethnic groups, the severity of these disparities becomes evident. As of March 6, 2021, AAs exhibited higher COVID-19 related mortality rates (236 vs. 124 per 100,000 population) and hospitalization rates (810 vs. 245 per 100,000

population) compared to Whites (42-44). A study indicated that, compared to White patients, AA patients admitted to hospitals displayed more severe COVID-19 symptoms upon admission, which resulted in a greater likelihood of needing intubation, intensive care, and even a higher risk of death (45). Another study, which analyzed electronic health records (including patients from 53 health systems across 21 states), found that among patients testing positive for COVID-19, AA patients had a higher risk for hospitalization and death compared to White patients, even after controlling for underlying health conditions and socioeconomic characteristics (46). These research findings underscore the urgent need to address health disparities, not only by acknowledging them but by implementing targeted interventions to bridge the health equity gap exacerbated by the pandemic.

1.5 Challenges in AA communities

AA communities have encountered unique challenges in navigating the COVID-19 pandemic, particularly concerning vaccination. These challenges are related to historical injustices and deeply rooted in structural racism, manifesting in disparities across health care, education, housing, employment, and wealth (39, 47, 48). The intergenerational continuity of such disparities causes a significant mistrust in the health care system and skepticism towards emergent medical interventions, including COVID-19 vaccines. These historical and contemporary injustices in health care have led to a hesitancy within AA communities to accept COVID-19 vaccines as safe, effective, or accessible (49). A recent national survey revealed a staggering 42% of AA respondents would not get COVID-19 vaccines as soon as it becomes available, with the majority saying “no” because they “did not trust the health care system” (50). In addition, 30% of

AA respondents expressed a desire for more information about the vaccine, pointing to a significant need for effective communication and education (50). The widespread vaccine hesitancy and diminished vaccine confidence within AA communities are further influenced by social norms, cultural discourse, risk perceptions, and misinformation (51, 52). In some AA communities, there is a prevalent social norm that prioritizes natural immunity over vaccination, which is often reinforced by cultural narratives that distrust medical interventions. Moreover, misinformation circulating on social media platforms about vaccine side effects has significantly skewed risk perceptions, leading many to overestimate the dangers of vaccination while underestimating the risks of COVID-19 itself.

Health agencies, including the CDC, have undertaken efforts to improve vaccine access and address misconceptions, but these efforts face challenges due to deep-rooted mistrust in the health care system (53-57). This lack of trust stems from a long history of abuse and exploitation by medical entities, with the tragedy of the Tuskegee syphilis experiment (58-61). Compounding these issues are socioeconomic inequities, which limit access to safe housing, transportation, and medical care, thereby increasing the risk of exposure to COVID-19 (62). Recent studies found that COVID-19 cases and deaths are disproportionately higher among essential workers who are predominantly occupied by AAs (63). An analysis of county-level data for 3,142 U.S. counties further illustrates this finding, showing that counties with a higher proportion of the AA population and adults with less than a high school education had disproportionately higher COVID-19 cases and deaths (64). Furthermore, structural barriers to COVID-19 vaccination such as navigating the vaccination scheduling system, limited appointment availability, and

locating convenient vaccination centers may also contribute to low vaccination rates in AA communities (65).

This dissertation investigated the multifaceted factors influencing COVID-19 vaccination in AA communities in South Carolina (SC). Focusing on both individual and structural level factors, this dissertation: 1) investigated how intrapersonal and interpersonal factors affect AAs' vaccination behavior, using individual level data; and 2) examined the structural level factors that affect AAs' vaccination rates, utilizing population level data for a comprehensive analysis. By exploring these dimensions, the study findings promised to deepen our understanding of the barriers and challenges affecting vaccination among AA communities. Moreover, these findings provided insights into the necessary resource allocation and interventions needed to support vaccination efforts, ultimately guiding policy recommendations and initiatives designed to improve the health outcomes and quality of life within AA communities.

1.6 Aims of the dissertation study

The dissertation informed a broader research agenda to gain an in-depth understanding of the multilevel factors impacting COVID-19 vaccination behavior among AAs in SC, within the context of the COVID-19 pandemic. In addition, the dissertation examined potential interactions among these factors, thereby providing a comprehensive picture of how factors interplay to affect vaccination behavior among AA communities. To achieve these objectives, the analysis drew from different data sources, including survey data collected through a COVID-19 vaccination promotion project and publicly available datasets (detailed further in the Methodology chapter). The dissertation achieved the following specific aims:

Aim 1 (study 1 – intrapersonal level): Assessed the extent to which confidence in COVID-19 vaccines mediated the association between perceived barriers to vaccination and vaccination behavior among AAs. This aim also examined a moderating effect of COVID-19 vaccine information-seeking behavior on the relationship between perceived barriers to vaccination and confidence in COVID-19 vaccines (Figure 1.2).

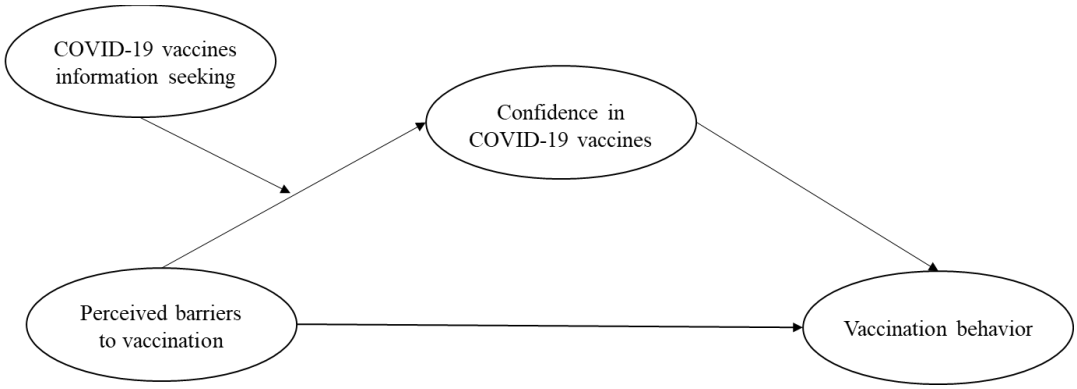

Figure 1.2 Study 1 hypothesized moderated mediation model

Hypothesis 1a: There is a negative association between perceived barriers to vaccination and vaccination behavior among AAs, where the greater the perceived barriers to vaccination, the less likely they are to get vaccinated.

Hypothesis 1b: Confidence in COVID-19 vaccines mediates the association between perceived barriers to vaccination and vaccination behavior.

Hypothesis 1c: COVID-19 vaccine information seeking behavior moderates the relationship between perceived barriers to vaccination and confidence in COVID-19 vaccines. The relationship will be less negative for AAs with COVID-19 vaccines information seeking behavior.

Aim 2 (study 2 – interpersonal level): Assessed the extent to which confidence in COVID-19 vaccines mediated the association between health care providers' recommendations and vaccination behavior among AA communities. This aim also

investigated a moderating effect of trust in public health agencies on the relationship between health care providers' recommendations and confidence in COVID-19 vaccines (Figure 1.3).

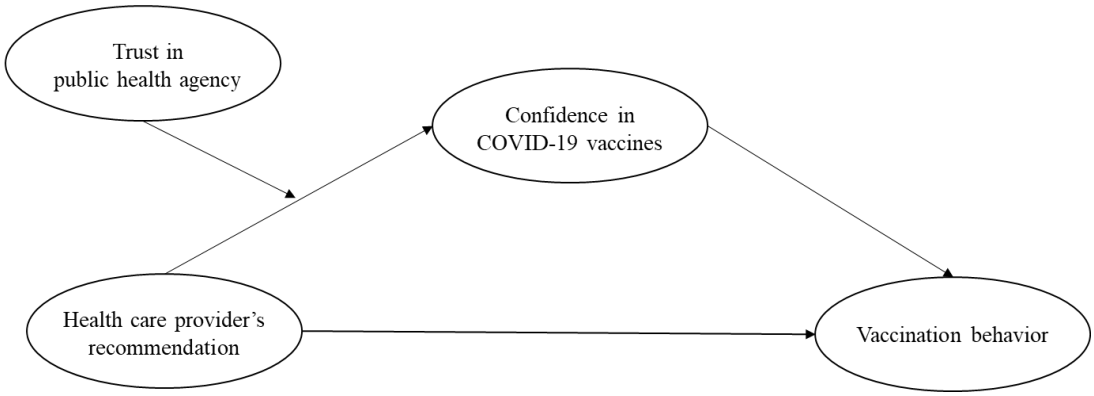

Figure 1.3 Study 2 hypothesized moderated mediation model

Hypothesis 2a: Health care providers' recommendations for COVID-19 vaccination is positively associated with vaccination behavior among AAs, where AAs who receive recommendations from their health care providers are more likely to engage in vaccination.

Hypothesis 2b: Confidence in COVID-19 vaccines mediates the association between health care providers' recommendations and vaccination behavior.

Hypothesis 2c: Trust in public health agency moderates the relationship between health care providers' recommendations and confidence in COVID-19 vaccines. The relationship will be more positive for AAs with a higher level of trust in public health agency.

Aim 3 (study 3 – structural level): Further investigated health disparities affected by structural level factors between AAs and Whites in the context of COVID-19 vaccination. The third aimed to examine the association between structural level factors

(e.g., racial residential segregation) and COVID-19 vaccination rates, utilizing county level data from the State of SC.

Hypothesis 3a: Racial residential segregation is negatively associated with COVID-19 vaccination rates in AA populations, suggesting that areas with higher levels of segregation will demonstrate lower vaccination rates compared to less segregated areas.

Hypothesis 3b: AA populations in counties with higher levels of socioeconomic disadvantage have lower COVID-19 vaccination rates compared to White populations in the same counties.

CHAPTER 2

BACKGROUND AND SIGNIFICANCE

2.1 Vaccination rates among AA communities

The COVID-19 pandemic has disproportionately affected AA communities in the U.S., resulting in higher rates of morbidity, severe illness, and mortality compared to other racial and ethnic groups (66-68). Studies have shown that AAs have 1.4 times higher infection rates, 3.7 times higher hospitalization rates, and 2.8 times higher death rates from COVID-19 than their White counterparts (69, 70). To control the spread of COVID-19 and reduce the severity of the disease, vaccination is one of the most effective tools. Not only are high vaccination rates (75% to 90%) necessary to achieve herd immunity, but equitable vaccination reduces disparities in COVID-19-related morbidity and mortality across racial and ethnic groups (71, 72). The high level of vaccination hesitancy in AA communities is one of the main reasons for racial disparities in vaccination rates. During the initial phase of COVID-19 vaccination in January 2021, only 48% of AA adults were willing to be vaccinated, compared with 60% of their White counterparts (38). This hesitancy resulted in a significant disparity in vaccination rates. Between January and March 2021, 54.8% of eligible Whites were vaccinated, while only 32.0% of AAs were vaccinated (37).

2.2 Barriers to vaccinations in AA communities

Barriers to vaccination within AA communities are multifaceted and span various levels, encompassing intrapersonal, interpersonal, institutional, community, and policy

levels (73, 74). At the intrapersonal level, barriers are often rooted in knowledge, perceptions, and personal beliefs about COVID-19 vaccines (73). Factors such as AAs' personal experiences or apprehensions regarding the safety and efficacy of vaccines safety and efficacy, compounded by historical adverse interactions with health care providers and limited understanding of immunization benefits, significantly influence AAs' willingness to get vaccinated (75). Moreover, fears about potential side effects and a general skepticism stemming from historical and ongoing injustices in health care contribute to hesitancy towards accepting COVID-19 vaccines as safe and effective (53, 76). At the interpersonal level, the influence of social relationships plays an important role in shaping vaccination decisions (77). The opinions and attitudes of family members, friends, and health care professionals can significantly impact AAs' attitudes and intentions on vaccination, either encouraging or dissuading them from getting vaccinated (77).

At the institutional level, public vaccination hesitancy is exacerbated by misinformation and conspiracy theories on social media (47, 66-68). Institutional level barriers also cause vaccination disparities in AA communities, primarily due to the availability and accessibility of community health services (78). The supports and resources available within communities are often beneficial in making timely health care decisions, especially regarding vaccination (79). These resources not only provide crucial information about vaccines but also play an important role in promoting vaccination. However, residential segregation and the unequal distribution of health care resources have made it difficult for many AA communities to access these supports and resources (80). Specifically, in SC, residential segregation between AA and White populations is

quantified by an index of dissimilarity, with a state overall value at 48 (81). Eight counties with indices over 42, indicating higher levels of segregation (Figure 2.1) (81). Further intensifying these disparities, 41 out of 46 SC counties have been designated as Health Professional Shortage Areas, with limited to access to health care and health care professionals (82). This shortage, characterized by a physician to patient ratio that is 23% below the national average (83). These barriers not only prevent the effective dissemination of reliable vaccine information, but also limits the ability of these communities to access timely and effective health care services (54-57, 84). Health agencies, including the CDC, have made great efforts to promote COVID-19 vaccination. However, the prevalent spreading of misinformation and disinformation regarding COVID-19 vaccines continues to cause concerns among AA communities, which in turn exacerbating their vaccination hesitancy (85).

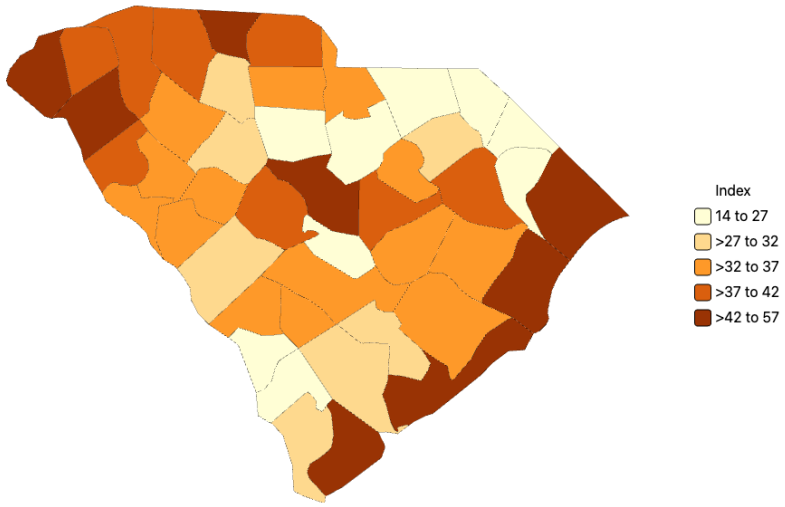

Figure 2.1 Residential segregation (AA/White) for South Carolina by county (Index of dissimilarity where higher values indicate greater residential segregation. All races, both sexes, all ages, 2017-2021) (81)

At the community level, lower rates of community vaccination could result in low perceived risk regarding COVID-19 (86). If a large proportion of the community remain

unvaccinated, it creates an implicit message that the COVID-19 threat is not serious enough to receive vaccination. At the policy level, health policy development and implementation, uneven distribution of health care services, and lack of targeting of services to specific communities pose further challenges (87). These institutional barriers not only impede vaccination promotion, but also reflect systemic inequities on vaccine distribution (88). Recognizing the dynamic interplay between these factors and how they work together to shape vaccination rates is critical to effectively addressing health disparities in AA communities.

2.3 Review of existing literature

2.3.1 Initial responses to COVID-19 vaccines among AAs

The COVID-19 vaccine has emerged as one of the methods to prevent COVID-19 infection, with evolving consensus that even when vaccination does not prevent infection, it substantially lowers the likelihood of severe illness and death in the event of infection (89). Moreover, glaring racial and ethnic disparities exist in COVID-19 vaccination (90, 91). During the outbreak of the pandemic, AA adults were the most hesitant to receive a potential COVID-19 vaccine when it became available (92). In January 2021, 52% of AA adults expressed “wait and see” attitude about getting vaccinated, compared to 40% of Whites (38). These differences in vaccine acceptance were primarily attributed to intention higher vaccine hesitancy, which includes a range of behaviors from the delay in acceptance or refusal of vaccine services in AA communities (93-96). In September 2021, across the United States, 75.88% (over 195 million people) of adults have received at least one dose of COVID-19 vaccines (22). Among people who have received at least one dose of the vaccine and for which data on race and ethnicity are available, 60.3%

were White, and 10.4% were AA, with data revealing continually lower COVID-19 vaccination rates among AAs when compared to their White counterparts (22). In most states, AA people are receiving smaller shares of COVID-19 vaccinations related to their shares of cases, total deaths, and the total population (22).

2.3.2 Community perspectives and trust issues

In addressing health disparities of COVID-19 vaccination within AA communities, a key barrier is prevailing mistrust of health care systems (78). This mistrust has historical roots and is exemplified by various community perceptions and experiences. For example, in Pittsburgh, AA community members expressed their concerns about being exploited for medical experiments, likening their participation in vaccine trials to being guinea pigs (97). A study focusing on AA adults living with HIV revealed an association between COVID-19 vaccination hesitancy and medical mistrust (95). Similarly, apprehensions regarding the safety of vaccines and skepticism towards health care systems were also prevalent among AA communities in Philadelphia (96).

With time, levels of COVID-19 vaccine hesitancy among AAs have decreased, while vaccination rates and intentions increase (98). By May 2021, data from the Kaiser Family Foundation Vaccine Monitor indicated that 56% of all AA adults had received at least one vaccine dose, 6% reported wanting to get vaccinated as soon as possible, 22% wanted to wait and see, 10% would get vaccinated only if required, and the remainder said they would definitely not (38, 65). These changes in attitude have been attributed to strategic local initiatives and policies intentionally targeting improvement of vaccine access, effective public communication efforts, and a transformation in social norms regarding vaccination (91, 99). While these statistics are promising and bode well for the

goal of attaining herd immunity, there remained then about one-third of AAs who were either hesitant or outright refusing and were likely so for a variety of reasons. Therefore, it is crucial to recognize and address the diverse factors influencing their decision-making when planning a public health intervention.

2.3.3 Comparisons with influenza vaccination attitudes

Exploring factors affecting vaccination in AA communities extends from influenza to COVID-19. White adults had higher flu vaccination coverage than AAs. During the 2021-2022 influenza season, the age-adjusted percentage of adults 65 years and older receiving the influenza shot was 67.8% for AAs compared to 75.7% for Whites (100). When examining the influenza vaccine, extensive research has demonstrated notable subgroup variations driving flu vaccine hesitancy among AAs (96). AAs have different experiences with the health care system, depending on gender, age, education, and income. Therefore, based on different combinations of these demographic factors, people are likely to have varying attitudes towards vaccination (101, 102). Research has found that older AAs and those with higher incomes AAs are more likely to have positive attitudes towards the flu vaccine, and they are less likely to endorse vaccine-related conspiracies and naturalist approaches towards protection from the flu than those who are younger and lower income (101, 102). Lower perceived disease severity and risk have also been associated with higher flu vaccine hesitancy. Studies have also uncovered experiences with discrimination, medical mistrust, and heightened awareness of one's racial identity within health care settings to be associated with hesitancy (101, 102). Another study found reporting of such experiences to be most prevalent among those of lower income (102).

2.3.4 Continuing causes of AA-White residential segregation

Residential segregation is a pronounced manifestation of structural racism and a profound determinant of health disparities, particularly among AA communities. Research suggests that residential segregation extends beyond geographic separation of racial and ethnic minorities (i.e., AAs) from Whites (103, 104). It is an indicator of systemic inequality with broad public health implications (103-105). Segregation has been shown to have a disproportionately negative impact on AAs' health outcomes, affecting their life expectancy and disease prevalence (65). While residential segregation is a fundamental cause of health disparities along racial lines, segregation also affects the accessibility and utilization of health care services (106, 107). Much research shows that segregation exacerbates disparities not just in health but also in access to employment and essential services, often requiring people in segregated areas to travel greater distances for employment and childcare, thereby hindering their access to essential services and further perpetuating health inequities (107, 108).

In geographic areas, while greater wealth may serve as a protective factor against the mortality rate from COVID-19, the presence of residential segregation could potentially impact this protective correlation with the actual health of residents. Localities such as counties and zip code areas, which are comprised of multiple neighborhoods, have been shown in the literature to lack equal distribution of key health-promoting resources that influence the population's exposure, resistance, and recovery processes during a pandemic (109-111). Furthermore, over a century of racial segregation and the underinvestment in AA communities, coupled with disproportionate investment in White communities, have led to significant health disparities among AA residents (112). The

residents of segregated counties experience worse health outcomes different domains, including disease mortality rates and personal health self-assessments (113-115).

Moreover, more research reveals that higher levels of residential segregation is associated with greater COVID-19 mortality (116, 117). The relationship between residential segregation and health outcomes may therefore complicate the well-established relationship between wealth and good health within a geographic area (118). While wealthier areas are typically associated with better health outcomes due to greater access to health resources and services, the presence of residential segregation can disrupt this pattern. If an area is segregated, the benefits of its wealth may not be experienced uniformly by all residents. High levels of residential segregation may concentrate health-promoting resources in predominantly White neighborhoods, thereby restricting access to these resources for residents living outside of these privileged neighborhoods. The health resources brought by area wealth, when distributed unevenly across specific communities, could weaken the overall health levels of an entire county and might even exacerbate the COVID-19 mortality. Conversely, in counties where there are lower levels of AA-White segregation, health-promoting resources are likely spread more evenly throughout neighborhoods, increasing access for a larger share of the population. The equitable distribution of resources such as recreational facilities, medical clinics, and grocery stores provides necessary support for residents to prevent exposure to COVID-19, resist infection, and recover if infected.

2.4 Research gaps

Although research on vaccination attitudes and intentions among AA populations has grown in recent years, contributing to our more comprehensive understanding of

factors influencing health disparities, there remains a significant knowledge gap in the field of research. First, existing studies primarily use national-level data, while these data provide valuable insights, more localized research is needed given the diversity in socioeconomic conditions, social norms, and community-specific factors across different regions. Localized studies can reveal the unique complexities of vaccination behaviors among AAs in SC and inform the development of more targeted vaccination promotion interventions. Second, most current research utilizes a single data source, which may limit the ability to explore multiple levels of factors. There are no studies that utilize individual- and population-level data to investigate intrapersonal, interpersonal, and structural level factors that influence vaccination. Third, racial disparities in COVID-19 related morbidity and mortality have been well-documented; however, limited studies explored the association between structural level factors and AA-White disparities. Therefore, the research aims to provide a more comprehensive and representative perspective on understanding the complex factors that affect vaccination behaviors among AA communities in SC by using multi-level and multi-source data.

2.5 Definitions of key variables

Perceived barriers to vaccination. Perceived barriers are defined as an individual's beliefs concerning the efficacy and potential costs related with vaccination behaviors (119). Perceived barriers can be classified as perceived clinical barriers and perceived access barriers to vaccination (119). Perceived clinical barriers refer to beliefs about concerns about potential side effects or doubts about vaccines' efficacy. Perceived access barriers are challenges related to obtaining vaccines. Challenges include vaccine availability, location of vaccination sites, and associated costs (119, 120).

Confidence in COVID-19 vaccines. Vaccine confidence is defined by public perceptions of three components: vaccine safety, effectiveness, and importance (94). Vaccine safety is the belief that vaccines will not cause harm or significant side effects. Effectiveness is the trust in vaccines' efficacy to provide immunity against the virus. Importance is understanding vaccines' role in controlling the pandemic and protecting the public. The novelty and rapid development of COVID-19 vaccines have made public confidence even more crucial in influencing vaccination (121).

Information seeking about COVID-19 vaccines. Information seeking about COVID-19 vaccines serves as a coping strategy that can significantly impact behavioral changes (122). Acquiring health information enables people to feel more adept and confident in managing their health, thus influencing their decision-making processes. This strategy not only empowers people with knowledge but also facilitates informed choices regarding vaccination, ultimately affecting public health outcomes.

Trust in public health agency. The level of trust in public health agencies is related to provide accurate, transparent, and timely information specifically related to COVID-19 vaccines (123). The trust encompasses the belief that public health agencies ensure the safety, efficacy, and equitable distribution of COVID-19 vaccines (123, 124).

Health care providers' recommendations. An individual's perception of societal expectation regarding vaccination is influenced by health care providers' recommendations (125). Social norms reflect the extent to which an individual believes that their social networks expect them to get COVID-19 vaccines based on a health care providers' recommendation (126). If individuals perceive a strong social expectation to

get the COVID-19 vaccine following a providers' recommendation, they are more inclined to get vaccinated (127).

Residential segregation. Residential segregation is commonly defined as the physical and spatial separation of racial or ethnic groups within a specified geographic area (80). Racial residential segregation is a fundamental cause of racial disparities in health due to the impact of residential segregation on socioeconomic conditions and access to resources (128). In the United States, the persistence of high levels of residential segregation among AAs exemplifies the persistent impact of structural racism (128). Segregated communities may face limited resources for health care, employment opportunities, and education; they also tend to have fewer digital connections, which further hinders their ability to effectively respond to health crises (80). This segregation may be directly related to COVID-19 vaccination efforts among AAs, as these socioeconomic barriers may contribute to disparities in vaccination rates (129). For example, the concentration of health care resources, including vaccination sites, in less segregated areas may mean that AAs living in more segregated communities have less access to these important services. This may result in lower vaccination rates and higher COVID-19 transmission and mortality in these communities.

2.6 Relevant theoretical frameworks

To explore the multifaceted factors influencing COVID-19 vaccination behavior among AAs, this dissertation drew upon several theoretical frameworks to understand the complex interplay of determinants at various levels. The Socio-Ecological Model offered a comprehensive foundation, offering a multidimensional perspective on how individual, interpersonal, institutional, community, and policy level factors collectively shape health

behaviors (130). It integrated individual factors like demographics and beliefs with broader societal dynamics, including the impact of public health campaigns and structural barriers, to understand the multifaceted influences on vaccine acceptance and hesitancy (130). This model underscored the importance of considering the entire ecosystem surrounding an individual, recognizing that health behaviors are the result of both personal circumstances and societal influences.

The Increasing Vaccination Model informed the investigation into determinants of vaccine acceptance, operating on the foundational principles of trust, convenience, and motivation (131). This model emphasized the importance of trust in health care providers and the accessibility of vaccination locations as critical factors influencing an individual's decision to vaccinate (131). Moreover, this model delved into motivational factors encouraging vaccination, such as perceived vulnerability to COVID-19 and the perceived benefits of vaccination, to better understand attitudes and intentions toward vaccination. The model was closely aligned with the study's investigation into perceived barriers and health care providers' recommendation underlying vaccine decision-making processes, especially within AA communities.

The Vaccine Hesitancy Determinants Model further contributed to the exploration of barriers to vaccination, focusing on the three critical factors of complacency, convenience, and confidence (132). By examining the perceived barriers AAs faced, including concerns over vaccine safety, misinformation, and mistrust in public health initiatives, the study aimed to unveil the complex factors affecting vaccination among AA communities (133, 134).

The Health Belief Model (HBM) offered a theoretical framework to comprehend and predict health-related behaviors, such as vaccination (135). Focused on AA vaccination hesitancy, the HBM suggested that perceived susceptibility, severity, benefits, and barriers are influential in vaccine acceptance. This model posited that individuals are more inclined to adopt health-promoting behaviors if they perceive a high level of threat from the disease, believe in the effectiveness of preventive measures, and view the barriers to action as minimal. Applying the HBM to the context of AAs' vaccination behavior provided valuable insights into the factors influencing their vaccination decisions and informed the development of targeted intervention strategies to address their specific concerns and barriers.

The integration of these models into the dissertation's conceptual framework enabled a holistic analysis of the complex factors contributing to COVID-19 vaccination disparities among AA communities. By encompassing intrapersonal, interpersonal, and structural level dimensions, the dissertation equipped a comprehensive understanding of the determinants of challenges and vaccine acceptance. This multidimensional approach highlighted the imperative to tackle various factors through tailored interventions and strategies. The goal was to promote equitable vaccination among AA communities, thereby contributing valuable insights into public health efforts aimed at mitigating health disparities and enhancing vaccination equity.

2.7 Conceptual framework

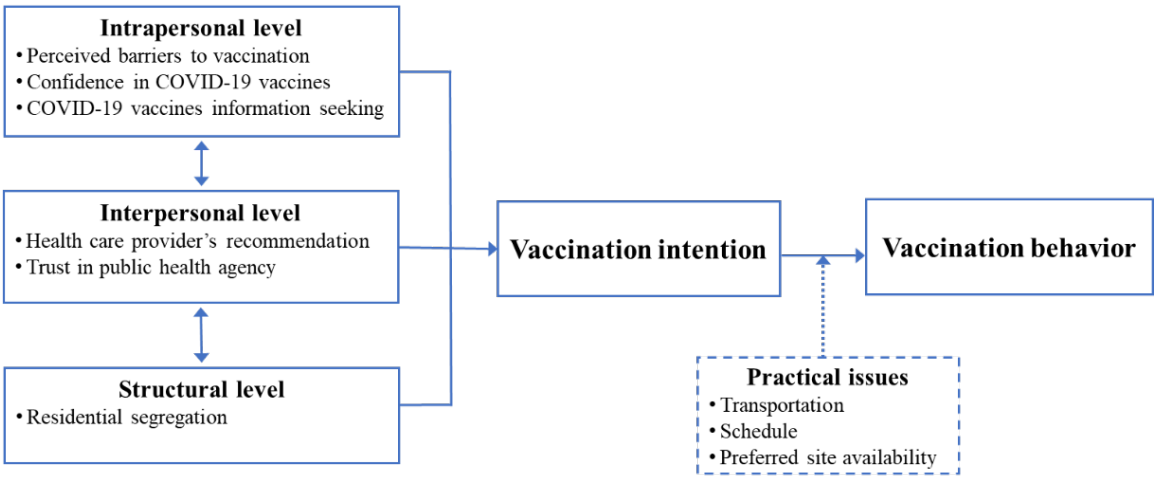

Figure 2.2 Conceptual framework

The conceptual framework presented in Figure 2.2 was adapted from the Socio-Ecological Model, the Increasing Vaccination Model (131), the Health Belief Model (135), and the Vaccine Hesitancy Determinants Model (133, 134) and used as a foundation to guide the dissertation's exploration into COVID-19 vaccination behaviors among AA communities. This adaptation embraced a comprehensive approach, recognizing the complex interplay of factors at intrapersonal, interpersonal, and structural levels that influence vaccination behavior.

2.8 Significances

2.8.1 Mitigating health disparities in AA communities

This dissertation was pivotal in addressing the disproportionate impact of COVID-19 on AA communities, which was further intensified by significant vaccination disparities. The study elucidated that AAs were less inclined to receive COVID-19 vaccines, a tendency rooted in structural barriers and a historical mistrust of the health care system (136). This mistrust has been compounded by historical injustices in

unethical medical treatments, such as the Tuskegee Syphilis Study (137, 138). By examining these disparities, the research contributed significantly to efforts aimed at mitigating health disparities, ensuring equitable vaccine access across diverse racial and socio-economic demographics. In providing an in-depth analysis, the dissertation filled a critical void in our comprehension of health disparities, particularly focusing on historically underserved communities. This focus underscored the paramount importance of fostering equitable health care practices and policies. The study's findings highlighted the need for a nuanced understanding of the barriers to vaccination within AA communities, including but not limited to, systemic inequities, misinformation, and the legacy of medical exploitation.

Through its comprehensive examination of the multifaceted factors influencing COVID-19 vaccination behavior among AAs, spanning intrapersonal, interpersonal, and systemic levels, the research offered insightful contributions to the discourse on health disparities. The dissertation proposed targeted interventions tailored to address the unique challenges faced by AA communities in accessing vaccinations. These interventions are grounded in the principles derived from the Socio-Ecological Model, the Increasing Vaccination Model, and the Vaccine Hesitancy Determinants Model, each providing a lens through which the complexities of vaccine hesitancy and acceptance can be understood and addressed. Moreover, the dissertation underscored the critical role of trust-building between healthcare providers and AA communities, advocating for strategies that enhance accessibility and address the specific concerns and informational needs of these populations.

2.8.2 Comprehensive analysis of factors influencing vaccination behavior

This dissertation extended beyond examining solely intrapersonal factors of vaccination behavior to encompass a broad spectrum of interpersonal and structural level factors within AA communities. Diverging from research limited to a singular aspect, this study embarked on an exploratory journey to understand a myriad of influences, including barriers to vaccination, levels of trust, information seeking behaviors, and the impact of health care providers' recommendations. This approach facilitated a nuanced comprehension of the intricate interplay among these diverse factors. The research setting in SC, a state with 67 Medically Underserved Areas and where over 95% of its population resides within a Primary Care Health Professional Shortage Area, underscored the pertinence of this study (82, 139). Given SC's significant AA population and its pronounced disparity in COVID-19 impact, the region's characteristics magnified the urgency and relevance of this research. The insights gleaned are pivotal for enhancing interventions tailored to the authentic needs of these communities, especially in regions similarly characterized by disparities in health care access.

2.8.3 Developing culturally sensitive interventions and policies

The findings from this dissertation were poised to significantly influence the creation of culturally sensitive interventions and policies. By delving into the interplay among various factors of vaccination behavior, ranging from individual barriers and information seeking behaviors to the influence of health care providers, this research identified critical areas for enhancing vaccination among AAs. This dissertation advocated for a strategically nuanced approach to vaccination campaigns, one that directly confronted health disparities and leveraged the power of culturally sensitive methodologies. The dissertation underscored the potential of targeted initiatives, such as

community-based vaccination efforts and health communication that is culturally aligned, to bridge the vaccination gap. Through a detailed analysis of these factors, the study illuminated pathways to influence, providing a foundation for future public health strategies aimed at elevating vaccine attitudes and addressing public health crises within AA populations and beyond.

2.9 Innovations

The study introduced several innovations that significantly advanced the understanding of vaccination behavior within AA communities. First, it positioned vaccination behavior as the primary research outcome, concentrating on the intricate interactions between intrapersonal, interpersonal, and structural level factors. This methodology was pioneering in its integration of several theoretical models, including the Socio-Ecological Model, the Increasing Vaccination Model, and the Vaccine Hesitancy Determinants Model. Through the synthesis of these frameworks, the dissertation conducted a multifaceted analysis to unravel the mechanisms through which various levels of factors related to vaccination influenced AAs' vaccination behavior. Furthermore, the research leveraged a rich dataset derived from a targeted vaccination outreach program alongside publicly available data sources. The employment of diverse datasets enabled a thorough investigation of vaccination disparities, addressing gaps previously identified in the research literature.

CHAPTER 3

METHODOLOGY

3.1 Overview of study setting

SC has a population of 5,282,634, about 26.3% were AA, and 68.9% were White (140). SC ranked 15th in the proportion of AA residents in the US, with the majority of AAs residing in the Midlands and Low Country regions of SC (Figure 3.1) (141). As of May 10, 2023, SC reported a total of 1,481,646 COVID-19 cases and 17,869 deaths (142). Through numerous efforts to promote vaccination, 71% of eligible residents (3,666,079 people) have received at least one dose of COVID-19 vaccines, and 60% (3,091,956 people) have been fully vaccinated (143). However, in this evolving context, AAs have been disproportionately affected by COVID-19, exhibiting higher rates of cases, hospitalizations, and deaths compared to their White counterparts. Meanwhile, AAs still lag behind Whites in vaccination rates (85). Existing data reveal racial disparities and challenges in responding to the COVID-19 pandemic and promoting vaccination, while also emphasizing the urgency of finding solutions with a focus on the SC region.

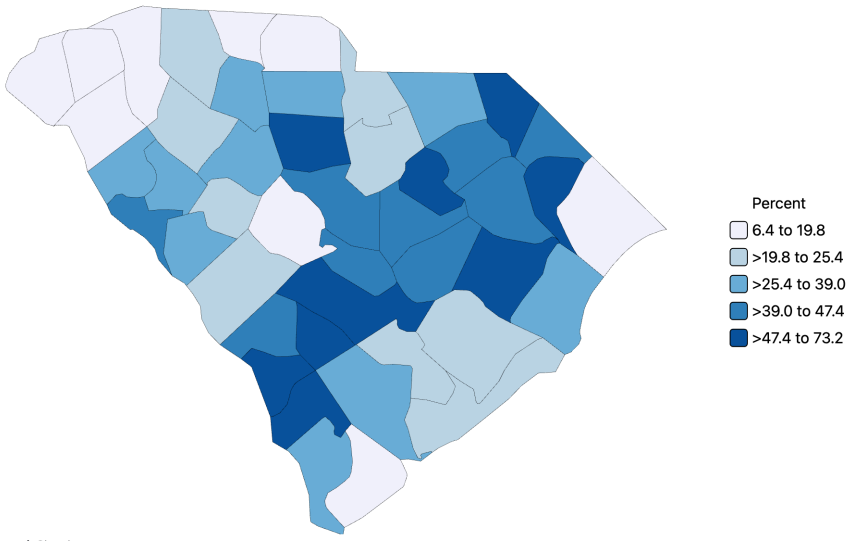

Figure 3.1 AA population for South Carolina by county, both sexes, all ages, 2017-2021

3.2 Survey data for studies 1 & 2

Overview of the COVID-19 vaccination promotion project. The study leveraged comprehensive data from the COVID-19 vaccination promotion project (Figure 3.2), designed to complement the CDC's Vaccine with Confidence Strategy (144, 145). This multifaceted initiative was collaboratively launched by the SC Department of Health and Environmental Control (SCDHEC) and the SC Community Health Worker Association (SCCHWA), targeting AA communities within SC counties where AAs comprise more than 40% of the population. The project aimed to promote confidence in COVID-19 vaccines and barriers to vaccination among AA communities in SC counties. The project's primary purposes were: 1) to identify socio-behavioral drivers, barriers, and facilitators of vaccination and explore potential strategies to promote COVID-19 vaccination, and 2) to train community health workers (as peer advocates) from the SCCHWA to address personal barriers by disseminating accurate vaccine information and sharing personal vaccination experiences within their networks, equip professional navigators to overcome infrastructural barriers to vaccination, and initiate a health

communication campaign to distribute promotional materials in the target communities. Moreover, the SCCHWA actively engaged in peer advocate recruitment and training, coordinating, and facilitating focus group discussions, and developing surveys for AA communities to understand the barriers and facilitators of COVID-19 vaccination.

A significant innovation of this project was the use of social marketing tokens and motivational interviewing techniques, which were instrumental in fostering trust within AA communities. These approaches, combined with a non-biased survey approach, facilitated stigma-free discussions, enabling community members to share their honest perceptions and attitudes towards COVID-19 vaccination. The use of branded social marketing tokens not only served as an incentive for community participation but also enhanced the authenticity of survey responses by encouraging research engagement.

Furthermore, the project underscored the importance of engaging peer opinion leaders, recognizing that AA communities show a preference for project facilitators who share their cultural values and deliver activities in culturally resonant ways. Peer advocates, identified as trusted messengers within their social networks, were meticulously recruited and trained across the SCCHWA's catchment areas. These individuals, selected based on criteria that included being of AA ethnicity, aged 18 or older, possessing a strong social influence, and a commitment to advocate for COVID-19 vaccination through sharing personal stories, played a pivotal role in the project's success. The SCCHWA's proactive role in recruiting and training these peer advocates, alongside coordinating survey development, was crucial in understanding and addressing the barriers and facilitators to COVID-19 vaccination within AA communities.

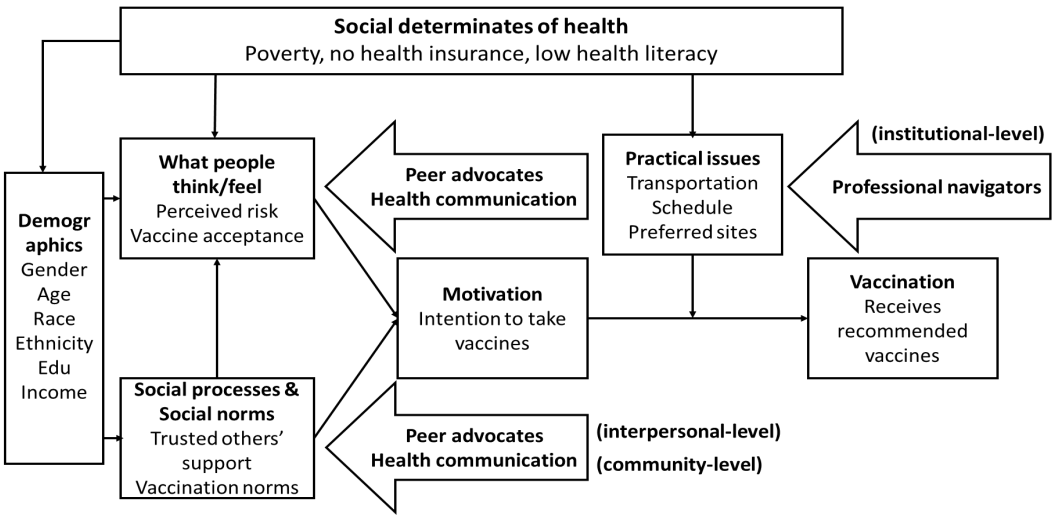

Figure 3.2 Rationale of the vaccination promotion project. Adopted from *Brewer et al. Increasing vaccination: Putting psychological science into action* (125).

3.3 Participants

Participants who met the eligibility criteria were invited to participate in the study. The individuals eligible for inclusion were AAs residing in SC, who were being contacted by a peer advocate for the first time, and who were literate in English. The exclusion criteria applied to AAs not residing in SC, those not being contacted by a peer advocate for the first time, or individuals with mental or physical conditions that precluded their ability to respond to survey questions.

3.4 Recruitment and data collection

Data collection was facilitated through the proactive engagement of peer advocates, who diligently motivated AA community members to participate. While distributing materials and disseminating information about COVID-19 vaccines, peer advocates reached out to AA community members using various strategies, including community outreach events, social media campaigns, and one-on-one interactions. Specifically, participants were recruited through flyers posted in churches and health care settings, at community events, and through word-of-mouth referrals from AA community

members who had previously completed the survey. All participants provided informed consent prior to their participation in the survey.

An online platform was utilized for data collection and management, enabling peer advocates to enter survey responses from engaged AA community members within their service counties. This digital method enhanced the efficiency of data collection and facilitated prompt and accurate data entry. The participant base grew steadily as new individuals were recruited into the study. Specifically, the cohort of participants engaged by peer advocates from November 8, 2021, to September 30, 2022, was earmarked for analysis. By October 7, 2022, a total of 2,029 AA community members had completed the survey.

3.4 Key measures for aims 1 & 2

In the dissertation, a set of measures was employed to achieve aims 1 and 2, which focused on the intrapersonal and interpersonal factors influencing COVID-19 vaccination behavior. These measures encompassed sociodemographic characteristics, perceived barriers to vaccination, trust in public health agency, information seeking about COVID-19 vaccines, confidence in COVID-19 vaccines, health care providers' recommendations, and vaccination behavior.

The survey was developed drawing on CDC-recommended survey items concerning COVID-19 vaccine confidence and uptake. The majority of the survey items were adapted from the National Immunization Survey Adult COVID Module (NIS-ACM), a random-digit-dialed cellular telephone survey of adults aged 18 years and older across all 50 states, the District of Columbia, selected local areas, and U.S. territories (72).

Dependent variable

The primary outcome variable assessed was *vaccination behavior*, determined using the NIS-ACM. Participants were asked, “Have you ever received at least one dose of the COVID-19 vaccine?” Response options were “Yes” and “No”.

Independent variables

Sociodemographic characteristics. Considered variables included the number of people living in the household, age, gender, county, and the month in which the participant was reached out to by a peer advocate.

Perceived barriers to vaccination. Participants reported various barriers to vaccination, with five questions from the NIS-ACM addressing appointment availability, knowledge of vaccination locations, accessibility of vaccination sites, inconvenient operating hours, and limited availability at preferred healthcare providers. The questions included “Does/did getting an appointment online make it difficult for you to get vaccinated?”, “Does/did not knowing where to get vaccinated make it difficult for you to get vaccinated?”, “Does/did hard to get to vaccination sites make it difficult for you to get vaccinated?”, “Does/did vaccination sites not being open at convenient times make it difficult for you to get vaccinated?”, and “Does/did the vaccine not being available to get from my preferred healthcare provider make it difficult for you to get vaccinated?”. Response options were “Yes” and “No”. Cronbach’s alpha was calculated as 0.879.

Health care providers’ recommendations. The NIS-ACM included a question on whether health care providers had recommended that the participant get a COVID-19 vaccine. Participants were asked the question, “Has a doctor or nurse, or other health

professional ever recommended that you get a COVID-19 vaccine?". Responses assessed ranging from "None" to "Almost all".

Trust in public health agency. Participants were asked their trust levels on public health agency by using one CDC recommended question, "How much do you trust the public health agencies that recommend COVID-19 vaccines?". Participants indicated their level of trust from "Do not trust" to "Fully trust".

Confidence in COVID-19 vaccines. Participants rated their perceived safety and effectiveness of COVID-19 vaccines based on two questions from the NIS-ACM. Safety was assessed by the question of "How safe do you think a COVID-19 vaccine is for you?". Response options were evaluated from "Not at all safe" to "Completely safe". Effectiveness was assessed by the question of "How effectiveness do you think getting a COVID-19 vaccine is to protect yourself against COVID-19?". Response options were evaluated from "Not at all important" to "Very important". Cronbach's alpha for this measure was 0.8.

Information seeking about COVID-19 vaccines. Participants were asked about their information seeking frequency based on one question from the NIS-ACM, "In the past month, how often have you tried to find information about COVID-19 vaccines?". Response options were measured from "Never" to "Often".

3.5 Data analysis for aims 1 & 2

Aim 1 – study 1: perceived barriers to vaccination – confidence in COVID-19 vaccines – vaccination behavior

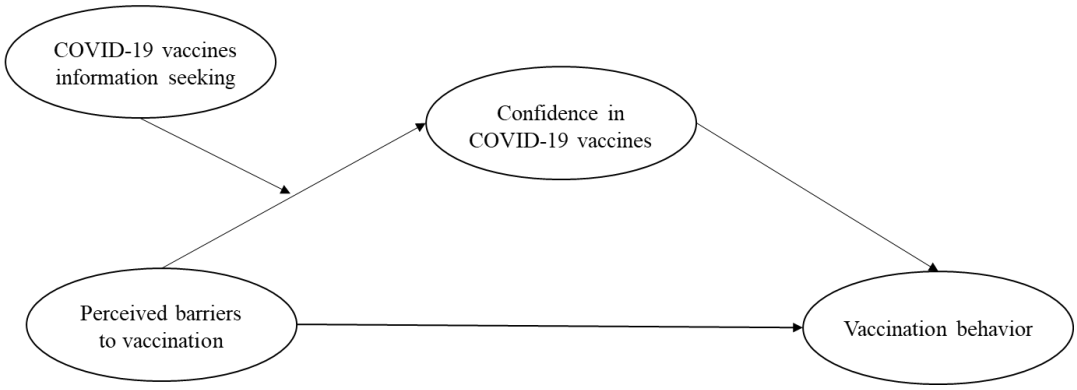

Figure 3.3 Study 1 moderated mediation model

In this study, structural equation modeling (SEM) was employed to investigate the mediating effect of "confidence in COVID-19 vaccines" in the association between "perceived barriers to vaccination" and "vaccination behavior", with "COVID-19 vaccines information seeking" acting as a moderator. Due to the dichotomous nature of the dependent variable, the weighted least squares mean and variance-adjusted (WLSMV) estimation was utilized to assess the path coefficients within the SEM framework (146). The goodness of model fit was assessed using several fit indices: the root mean square error of approximation (RMSEA), the comparative fit index (CFI), the Tucker-Lewis index (TLI), and the standardized root mean square residual (SRMR). Acceptable thresholds were identified as .90 (adequate) to .95 (good) for CFI and TLI; .05 (good) to .08 (adequate) for RMSEA; and .08 (good) for SRMR. A model demonstrates a better fit with higher CFI and TLI values and lower RMSEA and SRMR values. To ascertain the significance of the mediation and moderated mediation effects, bootstrapping was utilized to obtain confidence intervals for indirect effects. Demographic variables that did not significantly influence the model were excluded stepwise. All statistical analyses were conducted using R software (version 4.2.0), with the 'lavaan' package applied for the SEM analyses.

Table 3.1 Confirmatory Factor Analysis – perceived barriers to vaccination

	Factor	Estimate	Standard Error	z-value	p-value	CI.lower	CI.upper
1	f =~ barriers to online appointment	1	0			1	1
2	f =~ barriers to known locations	1.1	0.037	29.758	<.001	1.027	1.172
3	f =~ barriers to vaccination sites	0.991	0.035	28.389	<.001	0.923	1.06
4	f =~ barriers to convenient hours	1.163	0.039	29.66	<.001	1.086	1.239
5	f =~ barriers to preferred health care providers	1.175	0.04	29.656	<.001	1.097	1.253

*CI: 95% Confidence Interval.

The Confirmatory Factor Analysis (CFA) indicated a strong model fit, with significant p-values ($p < .001$) for all items, demonstrating the adequacy of the specified model in capturing the data. The factor loadings for the constructs, representing barriers to online appointments, known locations, vaccination sites, convenient hours, and preferred health care providers, on the latent factor were substantial, with estimates ranging from 0.991 to 1.175. These high factor loadings underscore the strong representation of each item by the latent construct of perceived barriers to vaccination. The significant z-values, exceeding 28 in all cases, confirmed the robustness of the factor loadings, highlighting that the items related to perceived barriers are highly representative of the latent construct in question. This CFA effectively demonstrated that the latent variable of perceived barriers to vaccination significantly explained the variance observed in the specific barriers measured, affirming the construct's relevance and importance in understanding vaccination behavior (Table 3.1).

Table 3.2 Correlation of barriers to vaccination

	1	2	3	4	5
1 Barriers to online appointments	1				
2 Barriers to known locations	0.594	1			
3 Barriers to vaccination sites	0.591	0.677	1		
4 Barriers to convenient hours	0.496	0.589	0.568	1	
5 Barriers to preferred health care providers	0.550	0.571	0.591	0.724	1

The analysis revealed moderate to strong positive correlations among all the identified barriers. Specifically, barriers to online appointments showed moderate to strong positive correlations with the other barriers, indicating that individuals encountering difficulties in making online appointments were likely to experience challenges across other areas as well. There was a strong correlation between barriers to known locations and barriers to vaccination sites, suggesting that individuals who were unaware of where to get vaccinated also frequently found the vaccination sites themselves inaccessible or inconvenient. Furthermore, a strong correlation was observed between barriers to convenient hours and barriers to accessing preferred healthcare providers for vaccination. This finding implies that individuals who perceived vaccination hours to be inconvenient also tended to report difficulties in accessing vaccines through their preferred healthcare providers (Table 3.2).

Table 3.3 Comparison of the proportion of participants who received at least one dose of COVID-19 vaccines with the SC vaccination rate, categorized by month of the vaccination promotion project

Year	Month	Participants			SC vaccination rate (any dosage)
		Total participants	Number of participants who received at least one dose	Proportion	
2021	November	60	51	85.00%	60.27%
2021	December	77	55	71.43%	62.77%
2022	January	61	48	78.69%	65.71%
2022	February	408	323	79.17%	66.57%
2022	March	263	205	77.95%	67.13%
2022	April	367	276	75.20%	67.31%
2022	May	208	171	82.21%	68.02%
2022	June	151	128	84.77%	68.45%
2022	July	224	173	77.23%	68.86%
2022	August	196	169	86.22%	69.32%
2022	September	14	13	92.86%	69.64%

Over the course of the study from November 2021 to September 2022, intervention participants consistently exhibited higher COVID-19 vaccination rates than the statewide averages in SC. Starting with an 85.00% vaccination rate among participants in November 2021, which already surpassed the state's rate of 60.27%, the intervention saw its highest success in September 2022, achieving a remarkable 92.86% vaccination rate, in stark contrast to the state's rate of 69.64%. This trend highlighted the efficacy of the intervention in enhancing vaccine uptake, particularly notable in months like August and September 2022, where participant vaccination rates significantly exceeded state averages, underscoring the impactful role of targeted intervention strategies in promoting health behaviors within specific communities (Table 3.3).

Aim 2 – study 2: health care providers' recommendations – confidence in COVID-19 vaccines – vaccination behavior

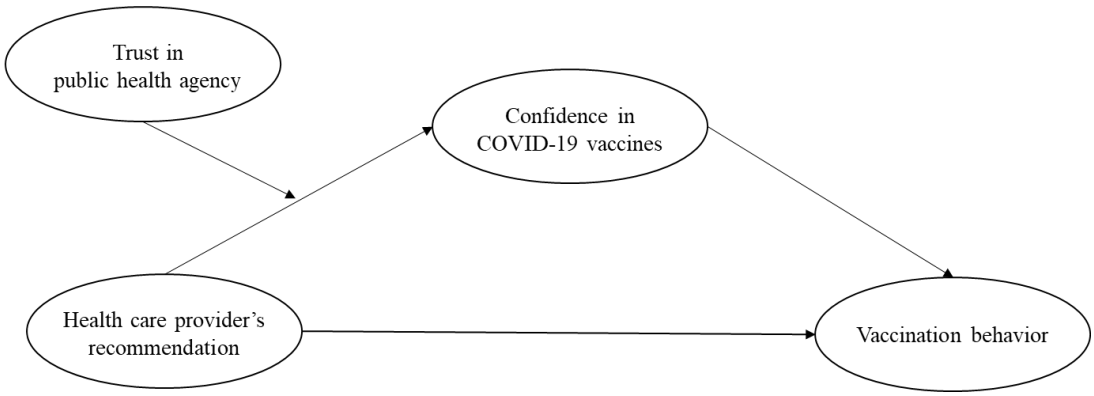

Figure 3.4 Study 2 moderated mediation model

In Study 2, the mediation effect of "confidence in COVID-19 vaccines" on the relationship between "health care providers' recommendations" and "vaccination behavior" was explored, along with the moderating effect of "trust in public health agency" on this mediation. Given the binary nature of the outcome variable, the analysis was conducted employing the weighted least squares mean and variance-adjusted (WLSMV) estimation within a structural equation modeling (SEM) framework. The model's fit was assessed using key indices, including the root mean square error of approximation (RMSEA), comparative fit index (CFI), Tucker-Lewis index (TLI), and standardized root mean square residual (SRMR). Acceptable thresholds were established at .90 to .95 for CFI and TLI, suggesting an adequate to good fit; .05 to .08 for RMSEA, indicating a good to adequate fit; and .08 for SRMR, denoting a good fit.

To robustly determine the significance of the mediation and moderated mediation effects, bootstrapping methods were utilized to generate confidence intervals for indirect effects, providing a non-parametric evaluation of these pathways. Demographic variables that did not significantly contribute to the model were systematically considered for

exclusion in a stepwise manner, streamlining the model to focus on its essential elements. All statistical analyses were performed using R software (version 4.2.0), with the 'lavaan' package facilitating the SEM analysis.

3.6 Overall analytic considerations

Covariate selection was determined through bivariate analyses that examined the relationships between sociodemographic characteristics such as the number of people living in a household, age, gender, and the outcome of vaccination behavior. Factors that yielded a p-value of less than 0.05 were further considered. These preliminary analyses guided the selection of covariates that were empirically substantiated and exhibited significant associations with vaccination behavior, thereby warranting their adjustment in the final model. Age, gender, household size, and previous COVID-19 infection were among the covariates included in the statistical models.

Among the total of 2,116 participants, a subset of 87 respondents (approximately 4%) indicated "follow-up" when queried about their history of prior contact. These respondents were subsequently excluded from the analysis to mitigate potential biases and maintain the integrity of the investigation into the effectiveness of vaccination promotion efforts. This decision was predicated on the rationale that including these respondents could introduce confounding variables, given their distinct interaction history, which might not be representative of the primary target population of the study. The analytical process then advanced with the refined dataset, ensuring that all included participants were contacted initially for the project without prior engagement history.

3.7 Overview of publicly available data for aim 3

Utilizing data from the CDC Vaccinations by County, SCDHEC Vaccination Dashboard, County Health Rankings, and HD*Pulse* Resources, county-level vaccination rates between AAs and Whites in SC were compared.

CDC COVID-19 Vaccinations in the United States, County. The CDC COVID-19 Vaccinations in the United States by county dataset provided comprehensive information on vaccine administration and vaccine equity at the county level across the United States (147). This dataset encompassed data from all vaccine distribution partners, including jurisdictional partner clinics, retail pharmacies, long-term care facilities, dialysis centers, Federal Emergency Management Agency and Health Resources and Services Administration partner sites, as well as federal entity facilities. The COVID-19 vaccination rate in each county was utilized as the dependent variable in the analysis.

SCDHEC Vaccination Dashboard. The SCDHEC Vaccination Dashboard is a digital platform designed to provide comprehensive and up-to-date information about COVID-19 vaccination efforts within the state of SC. This dashboard included county-level data and race-specific information (148). County level vaccination rates among AAs and Whites were used in the analysis.

County Health Rankings. The County Health Rankings provided data for nearly every county in the United States on four modifiable groups of health factors, including healthy behaviors, clinical care, physical environment, and socioeconomic conditions, and on health outcomes such as length and quality of life (149). This model, developed by the University of Wisconsin Population Health Institute in collaboration with the Robert Wood Johnson Foundation (150).

HDPulse Data Portal, National Institute on Minority Health and Health Disparities. The HD*Pulse* Data Portal characterized the burden of disparities across the United States and within communities (81). The data portal utilized publicly available U.S. population health surveillance data at the county, state, and national levels and included data related to health outcomes and their determinants. The data portal presented state-specific health estimates displayed by population group.

American Community Survey. The American Community Survey is an ongoing survey conducted by the U.S. Census Bureau that provides information on a yearly basis about the nation and its people (151). It is a comprehensive source of data that covers social, economic, housing, and demographic characteristics of the population (151).

3.8 Key measures for aim 3

Percent of AA or White population ages 18 and older who have completed a primary series. This rate calculated the percentage of the adult population (aged 18 and older) within AA or White groups that had completed the primary series of COVID-19 vaccination. This included individuals who had received the second dose of a two-dose vaccine or a single dose of a one-dose vaccine, again based on the jurisdiction and county where the vaccine recipient resided.

AA-White vaccination difference (fully vaccinated). This measure focused on the difference in vaccination rates between AA and White populations, specifically regarding the completion of the primary vaccination series. This rate shed light on the disparities in achieving full vaccination status between the two demographic groups, providing insight into the extent of vaccination equity or inequity within jurisdictions or counties.

Residential segregation – AA/White. The data was assessed from the HD*Pulse*: An Ecosystem of Minority Health and Health Disparities Resources and the 2020 County Health Rankings (81, 152). Residential segregation refers to the degree to which two or more groups live separately from one another in a geographic area. It is measured using an index of dissimilarity (153). The index of dissimilarity measures the percentage of a group's population that would have to change residence for each neighborhood to have the same percentage of that group as the metropolitan area overall (154). The index of dissimilarity measures how two groups (i.e., AA and White residents) are distributed across census tracts that make up the county. The residential segregation index rages from 0 (complete integration) to 100 (complete segregation) (81). The higher values of the index of dissimilarity indicate greater residential segregation between AA and White county residents.

Social association rate. The social association rate was derived from the publicly available data of the 2020 County Health Rankings database (152). The social association rate is a metric to assess social or community support at the county level. The rate measures the number of membership associations per 10,000 population. The numerator is the total number of membership associations in a county, while the total population of a county forms the denominator of this measure. The term "membership association" comprises membership in fitness centers, bowling centers, golf clubs, and civic, sports, religious, political, labor, business, or professional organizations.

Crowding (households with >1 person per room). The data of AA and White populations was derived from the HDPulse: An Ecosystem of Minority Health and Health Disparities Resources and the 2021 American Community Survey (ACS) (81, 151). A

housing unit is often considered crowded if it has more than one person to a room. The number of persons per room is calculated for a household by dividing the number of occupants by the number of rooms.

Education. The data of AA and White populations was derived from the HD*Pulse*: An Ecosystem of Minority Health and Health Disparities Resources and the 2021 American Community Survey (ACS) (81, 151). Persons with a bachelor's degree or higher are those who have received a bachelor's degree from a college or university, or a master's, professional, or doctorate degree. Data includes only people 25 years old and over. The percentages are obtained by dividing the counts of graduates by the total number of persons 25 years old and over.

3.9 Data analysis for study 3

For Hypothesis 3a, a correlation analysis was first conducted to determine the relationship between racial residential segregation and COVID-19 vaccination rates in AA and White populations. The hypothesis posited that higher levels of segregation would correlate with lower vaccination rates. Following the correlation analysis, a linear regression was performed to assess the impact of racial residential segregation on the difference of AA-White vaccination rates, thereby providing a more understanding of this association. Regarding Hypothesis 3b, the analysis similarly commenced with a correlation examination to explore the relationship between levels of socioeconomic disadvantage and COVID-19 vaccination rates in AA populations compared to White populations within the same counties. Subsequent regression analysis aimed to evaluate how socioeconomic disadvantage levels influenced COVID-19 vaccination disparities between AA and White populations.

CHAPTER 4

COVID-19 VACCINATION BEHAVIOR IN AFRICAN AMERICAN COMMUNITIES: A MODERATED MEDIATION MODEL OF PERCEIVED BARRIERS TO VACCINATION AND VACCINATION UPTAKE

4.1 Abstract

Background: Achieving substantial COVID-19 vaccination coverage is crucial in controlling the virus transmission. However, health disparities and inequities exist by race/ethnicity with African American (AA) communities reporting more barriers to vaccination and lower vaccination uptake. This study aimed to examine how AAs' perceived barriers to vaccination and confidence in COVID-19 vaccines influence their vaccination uptake.

Methods: Through a vaccination promotion initiative, we conducted a cross-sectional survey of AAs from 37 counties in South Carolina from November 2021 to September 2022. Using structural equation modeling, we assessed the mediating effect of AAs' confidence in COVID-19 vaccines on the association between perceived barriers (e.g., barriers to online appointments, known locations, vaccination sites, convenient hours, and preferred health care providers) to vaccination and vaccination uptake. In addition, we investigated how information seeking about COVID-19 vaccines moderated the effect of perceived barriers to vaccination on confidence in COVID-19 vaccines.

Results: A total of 2,029 AA participants (M age = 42.66 years) completed the survey. Results revealed that perceived barriers to vaccination were negatively associated with confidence in COVID-19 vaccines (b=-0.18, p<0.01), which in turn was negatively associated with vaccination uptake (b=-0.17, p<0.01). Moreover, AAs' confidence in COVID-19 vaccines mediated the relationship between perceived barriers and vaccination uptake. Information seeking about COVID-19 vaccines moderated the relationship between perceived barriers to vaccination and confidence in COVID-19 vaccines. The model's fit indices indicated a good fit, with a Comparative Fit Index of 0.974, a Tucker-Lewis Index of 0.962, a Root Mean Square Error of Approximation of 0.050, and a Standardized Root Mean Square Residual of 0.042.

Conclusion: AAs' perceived barriers to vaccination negatively affected their confidence in COVID-19 vaccines, and subsequently influenced their actual vaccination uptake. To address this issue, health care professionals should prioritize community engagement and collaborations to foster the dissemination of reliable vaccine information, thereby elevating vaccine confidence and acceptance within AA communities.

4.2 Introduction

The COVID-19 pandemic has exacerbated health disparities across racial and ethnic groups in the United States, particularly affecting African American (AA) communities (85). AA communities have disproportionately higher rates of infection, hospitalization, and mortality compared to their White counterparts (85). Studies showed that, compared to Whites, AAs experienced a 2.6 times higher rate of testing positive for COVID-19, a 4.7 times higher rate of hospitalization, and a 2.1 times higher mortality rate (37). Although COVID-19 vaccines have proven to be an effective measure for

preventing virus transmission and reducing the risk of severe illness, AAs have shown greater levels of hesitancy towards vaccination (155). During the pandemic outbreak, AA communities exhibited the most hesitancy regarding future COVID-19 vaccination (92). The higher vaccination hesitancy was indicated by delayed or refused vaccination behavior (93-96). In January 2021, 52% of AAs had a "wait and see" attitude about getting vaccinated, compared to 40% of Whites (38).

The vaccination hesitancy was caused by multifactorial barriers (73, 74). At the intrapersonal level, barriers are often rooted in knowledge, perceptions, and personal beliefs about COVID-19 vaccines (73). Factors such as AAs' personal experiences or apprehensions regarding the safety and efficacy of vaccines safety and efficacy, compounded by historical adverse interactions with health care providers and limited understanding of immunization benefits, significantly influence AAs' willingness to get vaccinated (75). Moreover, fears about potential side effects and a general skepticism stemming from historical and ongoing injustices in health care contribute to hesitancy towards accepting COVID-19 vaccines as safe and effective (53, 76). At the interpersonal level, the influence of social relationships plays an important role in shaping vaccination decisions (77). The opinions and attitudes of family members, friends, and health care professionals can significantly impact AAs' attitudes and intentions on vaccination, either encouraging or dissuading them from getting vaccinated (77).

Vaccine confidence was influenced by these factors, but increased vaccine confidence was a key driver in promoting vaccination (156). This confidence is predicated on beliefs regarding the vaccine's efficacy, safety, and the credibility of the processes by which it was developed and approved (157). Studies suggest that vaccine

confidence significantly impacts AAs' willingness to receive COVID-19 vaccines, with higher levels of confidence in vaccines associating with greater willingness to get vaccinated (158, 159). Moreover, the role of information seeking in health behavior theory suggests that individuals engaging in active information seeking about health interventions are more inclined toward positive health behaviors (160). Given the impact of COVID-19, social media have now emerged as an important source to seek, share and discuss health-related information (161). Prior research indicated that individuals' information seeking behavior in online information environment plays an important role in shaping their health behaviors (162). This proactive information seeking behavior can lead to increased vaccine literacy, which potentially improves vaccination rates (163). Research reports the wide use of social media for seeking information related to the COVID-19 pandemic and its positive influence on people's intention to receive COVID-19 vaccines (164, 165).

SC, with a significant proportion of AAs, faces the challenges of vaccination disparities during the pandemic (140). As of May 10, 2023, SC reported a total of 1,481,646 COVID-19 cases and 17,869 deaths (142). Through numerous efforts to promote vaccination, 71% of eligible residents (3,666,079 people) have received at least one dose of COVID-19 vaccines, and 60% (3,091,956 people) have been fully vaccinated (143). However, in this evolving context, AAs have been disproportionately affected by COVID-19, exhibiting higher rates of cases, hospitalizations, and deaths compared to their White counterparts. Meanwhile, AAs still lag behind Whites in vaccination rates (85). Existing data reveal racial disparities and challenges in responding to the COVID-

19 pandemic and promoting vaccination, while also emphasizing the urgency of finding solutions with a focus on South Carolina (SC).

Although previous studies have investigated the effects of vaccination barriers on intention or hesitancy to receive COVID-19 vaccines, our understanding of the mediation effect of vaccine attitudes (e.g., vaccine confidence) on vaccination behavior among AA communities remains limited (166-168). Therefore, this study aimed to fill the literature gap by examining whether AAs' confidence in COVID-19 vaccines mediates the association between their perceived barriers to vaccination and their actual vaccination behavior. In addition, the study aimed to examine the moderating effect of COVID-19 vaccine information seeking behavior between perceived barriers to vaccination and confidence in vaccines (Figure 4.1).

Hypotheses

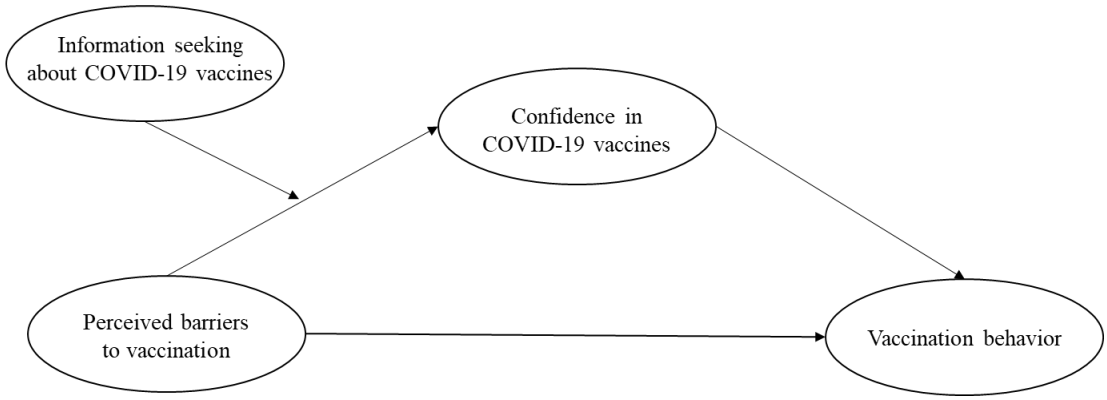

Figure 4.1 Hypothesized model

Hypothesis 1a: There is a negative association between perceived barriers to vaccination and vaccination behavior among AAs, where the greater the perceived barriers to vaccination, the less likely they are to get vaccinated.

Hypothesis 1b: Confidence in COVID-19 vaccines mediates the association between perceived barriers to vaccination and vaccination behavior.

Hypothesis 1c: COVID-19 vaccine information seeking behavior moderates the relationship between perceived barriers to vaccination and confidence in COVID-19 vaccines. The relationship will be less negative for AAs with COVID-19 vaccines information seeking behavior.

4.3 Methods

Participant recruitment

The study was part of larger project (i.e., COVID-19 vaccination promotion project) conducted among AA communities in SC from November 2021 to September 2022. Participants were recruited for a cross-sectional survey. Eligible AAs should 1) live in SC and 2) be able to read and speak English. The participant recruitment was led by the South Carolina Community Health Worker Association (SCCHWA). The study was approved by the Institutional Review Board of the University of South Carolina (Pro00111907).

Data collection

The survey was administered via pre-programed tablets to the participants in private rooms where the participants were most likely to feel safe and comfortable. The SCCHWA's community health workers (as peer advocates) were present during the survey to provide any necessary clarification. The data were collected with the informed consent of participants prior to their participation in the study. All the data were de-identified. The survey was written in English and completed within approximately 30 minutes. To facilitate data collection and management, an online platform was implemented, allowing peer advocates to input survey responses from engaged AA community members in their respective service counties. The participant pool expanded

continuously as new individuals were integrated into the study. Specifically, the participant cohort engaged by peer advocates between November 8, 2021 and September 30, 2022, was identified for analysis. As of October 7, 2022, a total of 2,029 AA community members in the target counties completed the survey.

Measures

The survey was developed drawing on CDC-recommended survey items concerning COVID-19 vaccine confidence and uptake. The majority of the survey items were adapted from the National Immunization Survey Adult COVID Module (NIS-ACM), a random-digit-dialed cellular telephone survey of adults aged 18 years and older across all 50 states, the District of Columbia, selected local areas, and U.S. territories (72).

Dependent variable

The primary outcome variable assessed was vaccination behavior, determined using the NIS-ACM. Participants were asked, “Have you ever received at least one dose of the COVID-19 vaccine?” Response options were “Yes” and “No”.

Independent variables

Sociodemographic characteristics. Considered variables included the number of people living in the household, age, gender, county, and the month in which the participant was reached out to by a peer advocate.

Perceived barriers to vaccination. Participants reported various barriers to vaccination, with five questions from the NIS-ACM addressing appointment availability, knowledge of vaccination locations, accessibility of vaccination sites, inconvenient operating hours, and limited availability at preferred healthcare providers. The questions

included “Does/did getting an appointment online make it difficult for you to get vaccinated?”, “Does/did not knowing where to get vaccinated make it difficult for you to get vaccinated?”, “Does/did hard to get to vaccination sites make it difficult for you to get vaccinated?”, “Does/did vaccination sites not being open at convenient times make it difficult for you to get vaccinated?”, and “Does/did the vaccine not being available to get from my preferred healthcare provider make it difficult for you to get vaccinated?”. Response options were “Yes” and “No”. Cronbach’s alpha was calculated as 0.879.

Confidence in COVID-19 vaccines. Participants rated their perceived safety and effectiveness of COVID-19 vaccines based on two questions from the NIS-ACM. Safety was assessed by the question of “How safe do you think a COVID-19 vaccine is for you?”. Response options were evaluated from “Not at all safe” to “Completely safe”. Effectiveness was assessed by the question of “How effectiveness do you think getting a COVID-19 vaccine is to protect yourself against COVID-19?”. Response options were evaluated from “Not at all important” to “Very important”. Cronbach’s alpha for this measure was 0.8.

Information seeking about COVID-19 vaccines. Participants were asked about their information seeking frequency based on one question from the NIS-ACM, “In the past month, how often have you tried to find information about COVID-19 vaccines?”. Response options were measured from “Never” to “Often”.

Data analysis

A structural equation modeling (SEM) was employed to analyze the mediating role of “confidence in COVID-19 vaccines” on the association between “perceived barriers to vaccination” and “vaccination behavior”, with “COVID-19 vaccines

information seeking" serving as a moderator. Due to the dichotomous nature of the dependent variable, the weighted least squares mean and variance-adjusted (WLSMV) estimation was utilized to assess the path coefficients within the SEM (146). The model's adequacy was appraised using several fit indices: the root mean square error of approximation (RMSEA), the comparative fit index (CFI), the Tucker-Lewis index (TLI), and the standardized root mean square residual (SRMR), with acceptable thresholds being .90 (adequate) to .95 (good) for CFI and TLI; .05 (good) to .08 (adequate) for RMSEA; and .08 (good) for SRMR. A better fit is indicated by higher CFI and TLI and lower RMSEA and SRMR values. To test the significance of the mediation and moderated mediation effects, bootstrapping was used to obtain confidence intervals for indirect effects. Demographic variables that do not significantly contribute to the model will be excluded in a stepwise manner. All statistical analyses were performed using R software (version 4.2.0), applying the 'lavaan' package.

4.4 Results

Table 4.1 Demographic characteristics of participants (n=2,029)

Variables	N (%) or Mean±SD
Age, Mean±SD	42.66 ± 18.71
15-25	505 (24.89%)
26-35	371 (18.28%)
36-45	278 (13.70%)
46-55	255 (12.57%)
56-65	336 (16.56%)
66-75	213 (10.50%)
76-85	53 (2.61%)
86-98	18 (0.89%)
Gender, n (%)	
Male	674 (33.22%)
Female	1347 (66.39%)
Others	8 (0.39%)
Contact date, n (%)	
2021 November	60 (2.96%)
2021 December	77 (3.79%)
2022 January	61 (3.01%)
2022 February	408 (20.11%)
2022 March	263 (12.96%)
2022 April	367 (18.09%)
2022 May	208 (10.25%)
2022 June	151 (7.44%)
2022 July	224 (11.04%)
2022 August	196 (9.66%)
2022 September	14 (0.69%)
Participant's County, n (%)	
Allendale	71 (3.50%)
Bamberg	81 (3.99%)
Barnwell	44 (2.17%)
Beaufort	4 (0.20%)
Calhoun	23 (1.13%)
Cherokee	11 (0.54%)
Chesterfield	98 (4.83%)
Clarendon	56 (2.76%)
Colleton	10 (0.49%)
Darlington	226 (11.14%)
Dillon	15 (0.74%)
Fairfield	13 (0.64%)
Greenville	8 (0.39%)
Hampton	80 (3.94%)
Horry	10 (.049%)
Jasper	9 (0.44%)
Kershaw	4 (0.20%)
Lee	162 (7.98%)
Lexington	78 (3.84%)
Marion	61 (3.01%)
Marlboro	18 (0.89%)
McCormick	24 (1.18%)
Newberry	10 (0.49%)
Orangeburg	284 (14.00%)
Richland	324 (15.97%)
Spartanburg	4 (0.20%)
Sumter	145 (7.15%)
Williamsburg	137 (6.75%)
York	9 (0.44%)
Aiken, Berkeley, Chester, Charleston, Greenwood, Laurens [1]	6 (0.30%)
Edgefield, Florence [2]	4 (0.20%)
Number of people living in household, n (%)	
0 (live alone)	70 (3.45%)
1	537 (26.47%)
2-4	1228 (60.52%)
5-8	194 (9.56%)
COVID-19 infection, n (%)	
Had COVID-19 infection	813 (40.07%)
Never been infected with COVID-19	1216 (59.93%)
Received at least one dose of COVID-19 vaccines, n (%)	
Yes	1612 (74.45%)
No	382 (18.83%)
Don't know	35 (1.72%)

1. One participant came from each county.

2. Two participants came from each county.

Table 4.1 provided an overview of the demographic characteristics of surveyed participants, totaling 2,029 individuals from African American communities. The age of these participants ranged from 15 to 98 years, with an average age of 42.66 years. The majority of participants, accounting for 56.87%, were aged 45 or younger. In terms of gender distribution, the survey comprised 33.22% male participants and 66.39% female participants. The counties with the highest number of participants were Richland (15.97%), Orangeburg (14%), and Darlington (11.14%). The data, spanning from November 2021 to September 2022, revealed a fluctuating participation rate throughout this period. Specifically, February (20.11%) and April (18.09%) of 2022 saw the highest levels of participant engagement. Information on household size was also included, showing that most participants resided in households of 2 to 4 individuals (60.52%), followed by single-person households (26.47%), and a smaller proportion lived alone (3.45%). Regarding COVID-19 infection status, about 40.07% of participants reported having been previously infected with the virus, while 59.93% had not. Notably, a significant portion (74.45%) of participants had received at least one dose of COVID-19 vaccines, demonstrating substantial vaccination rates within the surveyed population.

Table 4.2 Descriptive statistics of participants

		Total population N=2029	Male N=674	Female N=1347
Age	Mean	42.66	41.45	43.24
	SD	18.71	18.94	18.57
Confidence in COVID-19 vaccines	Mean	5.8	5.68*	5.86
	Range	(2,8)	(2,8)	(2,8)
Information seeking about COVID-19 vaccines	Mean	2.39	2.23**	2.47
	Range	(1,4)	(1,4)	(1,4)

* t-test p<.05; ** t-test p<.01

Table 4.2 provided descriptive statistics for the participant population, which included a total of 2,029 individuals, comprising 674 males and 1,347 females. Confidence in COVID-19 vaccines and information seeking about COVID-19 vaccines were key measures that exhibited differences between male and female participants. Female participants demonstrated a slightly higher average confidence level in COVID-19 vaccines (mean = 5.86) compared to their male counterparts (mean = 5.68), a difference that achieved statistical significance ($p < .05$). Furthermore, information seeking about COVID-19 vaccines also showed significant gender-based differences, with females engaging in more proactive information seeking behaviors (mean = 2.47) than males (mean = 2.23, $p < .01$).

A confirmatory factor analysis was performed to assess the unidimensionality of perceived barriers to vaccination. The results of the confirmatory factor analysis indicate that all loadings were significant for the sample.

Table 4.3 Decomposition of the effects on vaccination behavior

	b	se	z	p
Effect				
Perceived barriers to vaccination→vaccination behavior	-0.167	0.031	-5.385	<0.01
Mediating effect				
Perceived barriers to vaccination→ confidence in vaccines→vaccination behavior	-0.098	0.022	-4.511	<0.01

Table 4.3 outlined the effects on vaccination behavior, focusing on the role of perceived barriers to vaccination and their impact through a mediator of confidence in vaccines. There is a significant negative relationship between perceived barriers to vaccination and vaccination behavior ($b = -0.167$, $p < 0.01$). This result suggested that as

AAs' perceived barriers increased, the likelihood of vaccination behavior decreased. In addition, the study examined the mediation effect where confidence in vaccines mediated the relationship between perceived barriers to vaccination and vaccination behavior. The results showed AAs' confidence in vaccines mediated the association between perceived barriers to vaccination and vaccination behavior ($b = -0.098$, $p < 0.01$), indicating that perceived barriers led to decreased confidence in vaccines, which in turn negatively influenced vaccination behavior.

Table 4.4 Effects on vaccination bahavior and confidence in COVID-19 vaccines

		b	se	z	p
Vaccination behavior →					
Perceived barriers to vaccination	c	-0.167	0.031	-5.385	<.01
Confidence in COVID-19 vaccines	b	0.543	0.033	16.518	<.01
Age	f	0	0	0.188	<.01
Sex	g	0.018	0.018	1.035	<.01
Confidence in COVID-19 vaccines →					
Perceived barriers to vaccination	a	-0.181	0.041	-4.463	<001
Age	e	-0.008	0.001	-11.690	<.01
Sex	h	-0.063	0.023	-2.770	<.01

Table 4.4 outlined the effects between perceived barriers to vaccination, confidence in COVID-19 vaccines, vaccination behavior, and the effects of demographic variables such as age and sex. A positive relationship was identified between confidence in COVID-19 vaccines and vaccination behavior ($b = 0.543$, $p < 0.01$). Perceived barriers to vaccination were also negatively associated with confidence in COVID-19 vaccines ($b = -0.181$, $p < 0.01$). Age did not show a statistically significant effect on vaccination behavior but was found to be negatively associated with confidence in COVID-19 vaccines ($b = -0.008$, $p < 0.01$). Sex was associated with both vaccination behavior (b =

0.018, $p < 0.01$) and confidence in COVID-19 vaccines ($b = -0.063$, $p < 0.01$), indicating statistically significant but modest associations.

The fit indices for the model indicated a good model fit: CFI was 0.974, TLI was 0.962, RMSEA was 0.050, and SRMR was 0.042. A CFI value of 0.974 denoted a good fit to the data. The TLI value of 0.962 also suggested a good model fit. The RMSEA value of 0.050, with a 90% Confidence Interval (CI) ranging from 0.043 to 0.056, fell well below the accepted threshold of 0.08, indicating a good fit. Similarly, the SRMR value of 0.042, being under the 0.08 threshold, further confirmed the model's adequate fit.

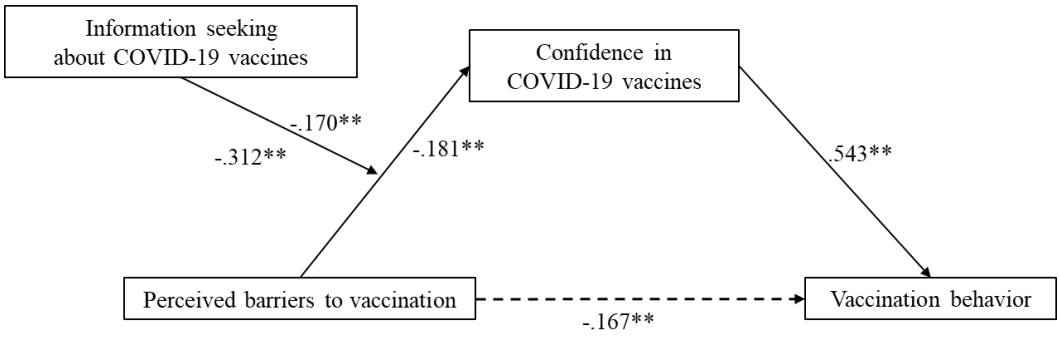

Figure 4.2 Moderated mediation model among perceived barriers to vaccination, confidence in COVID-19 vaccines, information seeking about vaccines, and vaccination behavior

Figure 4.2 presented a moderated mediation model, detailing the relationships among perceived barriers to vaccination, confidence in COVID-19 vaccines, information seeking about vaccines, and vaccination behavior. In the model, confidence in COVID-19 vaccines served as a mediator in the relationship between perceived barriers to vaccination and vaccination behavior. The significant negative path coefficient ($b=-0.167$, $p < .01$) from perceived barriers to vaccination behavior illustrated that greater perceived barriers were associated with a decrease in the likelihood of vaccination behavior. Information seeking about COVID-19 vaccines was depicted as a moderator in

the relationship between perceived barriers to vaccination and confidence in vaccines. This was evidenced by two path coefficients leading from perceived barriers to confidence in vaccines, which were differentiated by levels of information seeking. For those with lower information seeking behavior, the relationship was weaker ($b=-0.170$, $p < .01$), whereas for individuals with higher information seeking behavior, the relationship was stronger ($b=-0.312$, $p < .01$). The path from confidence in COVID-19 vaccines to vaccination behavior was positively strong ($b=0.543$, $p < .01$), indicating that higher confidence was significantly associated with increased vaccination behavior.

4.5 Discussion

The current study investigated the associations among perceived barriers to vaccination, confidence in COVID-19 vaccines, information seeking regarding COVID-19 vaccines, and vaccination behavior within AA communities in SC. Aligned with the hypotheses, the results elucidated an inverse relationship between AAs' confidence in COVID-19 vaccines and perceived barriers to vaccination, along with a positive association with vaccination behavior. Moreover, perceived barriers were found to negatively impact vaccination behavior indirectly by diminishing confidence in vaccines. Information seeking about COVID-19 vaccines also moderated the relationship between perceived barriers and vaccine confidence, suggesting that the manner and extent of seeking information can influence vaccine-related attitudes and decisions.

The relationship between barriers and vaccination behavior suggested that higher perceived barriers, such as difficulties with online appointment scheduling, unfamiliarity with vaccination site locations, inconvenient operating hours, and preferences for specific health care providers, are associated with reduced confidence, which subsequently

negatively influenced vaccination behaviors. Existing studies corroborate that access barriers related to availability, such as conflicts with employment and caretaking responsibilities during standard business hours, can impede vaccination uptake (125). The detrimental impact of these barriers is consistent with prior literature on disparities in vaccination intentions and behaviors for COVID-19, seasonal influenza, and HPV among AAs (54, 74, 169, 170). In addition, qualitative studies have revealed that AA participants reported technological access barriers, such as a lack of digital access and difficulties encountered by certain segments of the population in navigating online systems (157). The capacity for information seeking is closely tied to AAs' knowledge of COVID-19 vaccines, understanding of vaccine safety and efficacy, ability and confidence in communicating with health care providers, and the need for authoritative, credible sources of information to support their behavior (74).

The positive association between confidence in COVID-19 vaccines and vaccination behavior has implications for developing tailored messaging and interventions for AA communities. First, public health campaigns aimed at promoting COVID-19 vaccines should recognize and address structural racism and the understandable, multifaceted mistrust that exists due to historical injustices (48, 66). Acknowledging this mistrust as a legitimate response to AAs' experiences with racism is crucial. Second, such campaigns should facilitate open dialogues with scientists and health care providers who are seen as trustworthy and credible, to provide essential health information and respond to community members' questions.

Encouraging proactive information seeking behaviors emerged as a critical strategy in these efforts (171). By empowering individuals to seek information and ask

questions, public health initiatives can foster trust and reinforce vaccine confidence, thereby translating into actual vaccination behaviors. Indeed, the facilitating role of information seeking in building trust and confidence in vaccines is pivotal for turning intentions into actions.

Limitations

Several limitations should be acknowledged in the present study. First, the study utilized self-reported measures, which may cause response bias. Participants' responses may be influenced by social desirability, potentially leading to overestimation of barriers related to COVID-19 vaccination. Second, this study primarily utilized a survey approach to investigate the research hypotheses. While surveys offer valuable quantitative data, they may not capture the full complexity and nuances of the cultural context surrounding COVID-19 vaccination decision-making among AA communities. To obtain a more comprehensive understanding, future research should consider incorporating qualitative studies to gather detailed information and explore the specific experiences and perspectives of AA community members. Third, the survey sample was not representative. Since it is possible that only people interested in vaccination-related topics chose to attend the outreach events and thus were reached by peer advocates. Fourth, this study employed a cross-sectional design, preventing the establishment of causal relationships. Future studies need to employ longitudinal data to explore causality among the main variables.

4.6 Conclusion

The current study presented that AAs' vaccination behavior was indirectly influenced by their perceived barriers to vaccination. Information seeking behavior and a

higher level of confidence in COVID-19 vaccines can affect vaccination behavior positively. These findings demonstrate the need for targeted vaccination promotion interventions in AA communities, not only to increase awareness of the benefits and efficacy of COVID-19 vaccines, but also to reduce the perceived barriers associated with vaccination. By targeting scientific literacy and awareness in these communities, we can address the underlying factors that contribute to vaccination hesitancy. In addition, to address future public health crises, we need to take a proactive approach to building trust and confidence in the health care system among AA communities. Implementing community engagement and culturally sensitive health education programs is critical to improving vaccination behaviors.

CHAPTER 5

HEALTH CARE PROVIDERS' RECOMMENDATIONS, CONFIDENCE IN COVID-19 VACCINES, TRUST IN PUBLIC HEALTH AGENCY, AND VACCINATION UPTAKE AMONG AFRICAN AMERICAN COMMUNITIES: A MODERATED MEDIATION MODEL

5.1 Abstract

Background: Health care providers are pivotal in guiding vaccination decisions, which are particularly important in African American (AA) communities that have been disproportionately affected by the COVID-19 pandemic. The low vaccination rates in these communities underscore the need to understand the influence of health care providers to promote vaccination. This study aimed to examine how health care providers' recommendations impact vaccination behavior among AA communities in South Carolina.

Methods: A survey was conducted among AA community members in South Carolina from November 2021 to September 2022, gathering data on demographics, healthcare provider recommendations, trust in public health agencies, confidence in COVID-19 vaccines, and vaccination uptake. Structural equation modeling was employed to assess: 1) the mediating effect of AAs' confidence in COVID-19 vaccines in the association between health care providers' recommendations and AA's vaccination uptake, and 2)

the moderating effect of trust in public health agencies on the association between health care providers' recommendations and confidence in COVID-19 vaccines.

Results: A total of 2,029 AA participants (M age = 42.66 years) completed the survey. Results showed that health care providers' recommendations (as reported by participants) were positively associated with vaccination behavior ($b=0.007$, $p<0.01$). Confidence in COVID-19 vaccines mediated the relationship between health care providers' recommendations and AAs' vaccination uptake ($b=0.113$, $p<0.01$). Trust in the public health agencies was found to moderate the relationship between health care providers' recommendations and confidence in vaccines ($b=0.185$, $p<0.01$), with higher trust levels strengthening the impact of health care providers' recommendations on confidence in vaccines. The indices for model fit suggested an adequate to good fit, with a Comparative Fit Index of 0.932, a Tucker-Lewis Index of 0.901, a Root Mean Square Error of Approximation of 0.085, and a Standardized Root Mean Square Residual of 0.043.

Conclusion: Interventions aimed at promoting vaccination within AA communities should not only focus on amplifying the role of health care providers in vaccine advocacy but also on rebuilding and reinforcing trust in public health agencies. By adopting a dual approach that emphasizes both credible health care recommendations and the restoration of trust in public health systems, public health strategies can more effectively address vaccination uptake disparities among AAs.

5.2 Introduction

The COVID-19 pandemic has posed an unprecedented challenge to global health, triggering a race to develop and distribute effective vaccines (19). In the United States, the rollout of COVID-19 vaccines has been met with varying degrees of acceptance

among different demographic groups. African American (AA) communities, in particular, have shown hesitancy towards vaccination, which can be attributed to a complex interplay of multilevel factors (53, 76). This hesitancy is concerning because AAs have been disproportionately affected by COVID-19, with higher rates of infection, hospitalization, and mortality compared to other ethnic groups (95). Thus, understanding the factors influencing vaccination behavior in AA communities is critical for public health efforts aiming to mitigate the impact of the pandemic.

Extant literature has identified health care providers' recommendations as a significant predictor of vaccine uptake. A top facilitator of confidence is doctors' recommendation, motivating 62% Americans (172, 173). Such recommendations are often regarded as a trusted source of medical advice, potentially influencing patients' attitudes and intentions regarding vaccines (172, 173). However, the specific pathways through which health care providers' recommendations translate to actual vaccination behavior remain underexplored, particularly within AA populations. Moreover, the role of institutional trust, especially in public health agencies, is another dimension that may play a crucial role in shaping vaccination behavior. Trust in public health agencies has been found to affect individuals' health-related decisions and adherence to public health guidelines, yet its interaction with health care providers' influence has not been sufficiently examined in the context of COVID-19 vaccination (124).

Trust in public health agencies is a foundation of public health success, particularly in COVID-19 vaccination (174). The literature has shown that when individuals trust public health agencies, they are more likely to follow vaccination recommendations (124). However, this trust is not uniformly distributed across different

communities. In AA communities, distrust in health institutions has historical roots, such as the Tuskegee Syphilis Study, and persists due to ongoing disparities in health outcomes and perceived institutional racism (58-61). This distrust may act as a barrier to vaccine acceptance, as individuals who are skeptical of the motives and competence of public health agencies might disregard their recommendations (49). Moreover, promoting trust can be a powerful facilitator of vaccination, suggesting that public health strategies should include measures to build and restore trust within AA communities (175).

Vaccine confidence was influenced by these factors, but increased vaccine confidence was a key driver in promoting vaccination (156). This confidence is predicated on beliefs regarding the vaccine's efficacy, safety, and the credibility of the processes by which it was developed and approved (157). Studies suggest that vaccine confidence significantly impacts AAs' willingness to receive COVID-19 vaccines, with higher levels of confidence in vaccines associating with greater willingness to get vaccinated (158, 159). For AAs, confidence in COVID-19 vaccines has been undermined by concerns about the speed of vaccine development and fears of potential side effects. Understanding the mediating role of vaccine confidence between provider recommendation and vaccination behavior is thus imperative for designing interventions that effectively increase vaccine uptake in AA communities.

The rise of misinformation, particularly through social media, has become a significant public health challenge in the COVID-19 pandemic (176). Misinformation can contribute to vaccine hesitancy by sowing doubts about vaccine safety and effectiveness (177). AA communities are not immune to the influence of misinformation, with social media, friends, and family sometimes being sources of misleading information (177).

Contrarily, health care providers can serve as trusted messagers against misinformation when they are trusted sources of information. The challenge lies in the competition for trust, where misinformation may overshadow accurate information if it aligns with pre-existing beliefs or is more accessible (157).

Several theoretical models have been proposed to understand the decision-making process in health behaviors, including vaccination. The Health Belief Model suggests that personal beliefs about health risks and benefits are key determinants of health-related behaviors (135). The Theory of Planned Behavior posits that attitudes, subjective norms, and perceived behavioral control lead to the formation of behavioral intentions and subsequent behaviors (178). These models can be applied to understand the complex interplay of trust, confidence, and misinformation in vaccination decision-making. In addition, the Information-Motivation-Behavioral Skills Model emphasizes the role of information, motivation, and behavioral skills in health behavior performance and could be instrumental in unraveling the moderated mediation pathways in vaccination behavior (179).

The present study aimed to investigate the mechanisms underlying COVID-19 vaccination behavior in AA communities in South Carolina (SC). Specifically, this study aimed to examine 1) the mediation effect of AAs' confidence in COVID-19 vaccines in the relationship between health care providers recommendations and their actual vaccination behavior, and 2) the moderation effect of trust in public health agencies in the relationship between health care providers' recommendations and AAs' confidence in vaccines. Through a methodical analysis of these relationships, the study endeavors to contribute to the scholarly discourse on vaccine uptake and provide actionable insights

for health communication strategies targeting AA communities during the COVID-19 pandemic and future public health crises.

Hypotheses

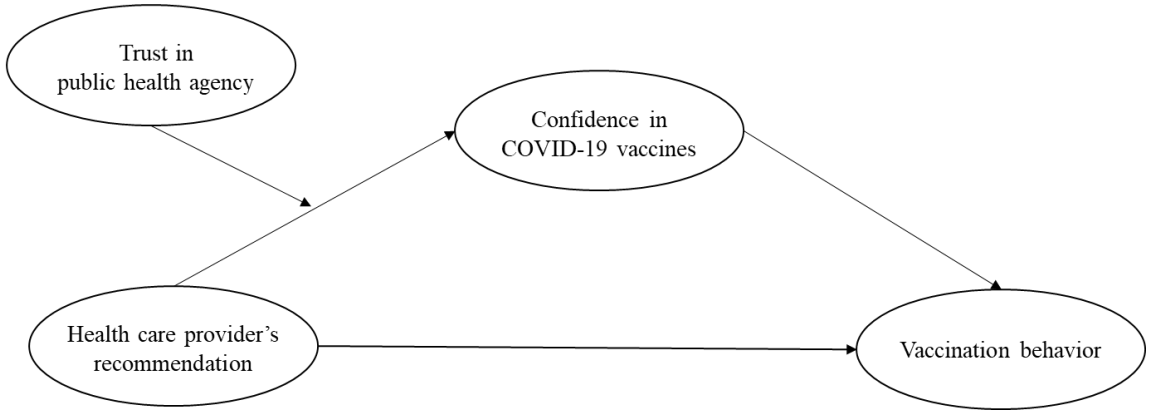

Figure 5.1. Hypothesized model among health care providers' recommendation, trust in public health agency, confidence in COVID-19 vaccines, and vaccination behavior.

Hypothesis 1: Health care providers' recommendations for COVID-19 vaccination is positively associated with vaccination behavior among AAs, where AAs who receive recommendations from their health care providers are more likely to engage in vaccination.

Hypothesis 2: Confidence in COVID-19 vaccines mediates the association between health care providers' recommendations and vaccination behavior.

Hypothesis 3: Trust in public health agency moderates the relationship between health care providers' recommendations and confidence in COVID-19 vaccines. The relationship will be more positive for AAs with a higher level of trust in public health agency.

5.3 Methods

Participant recruitment

The study was part of larger project (i.e., COVID-19 vaccination promotion project) conducted among AA communities in SC from November 2021 to September 2022. Participants were recruited for a cross-sectional survey. Eligible AAs should 1) live in SC and 2) be able to read and speak English. The participant recruitment was led by the SC Community Health Worker Association (SCCHWA). The study was approved by the Institutional Review Board of the University of South Carolina (Pro00111907).

Data collection

The survey was administered via pre-programed tablets to the participants in private rooms where the participants were most likely to feel safe and comfortable. The SCCHWA's community health workers (as peer advocates) were present during the survey to provide any necessary clarification. The data were collected with the informed consent of participants prior to their participation in the study. All the data were de-identified. The survey was written in English and completed within approximately 30 minutes. To facilitate data collection, an online platform was implemented, allowing peer advocates to input survey responses from engaged AA community members in their respective service counties. The participant pool expanded continuously as new individuals were integrated into the study. Specifically, the participant cohort engaged by peer advocates between November 8, 2021 and September 30, 2022, was identified for analysis. As of October 7, 2022, a total of 2,029 AA community members in the target counties completed the survey.

Measures

The survey was developed drawing on CDC-recommended survey items concerning COVID-19 vaccine confidence and uptake. The majority of the survey items

were adapted from the National Immunization Survey Adult COVID Module (NIS-ACM), a random-digit-dialed cellular telephone survey of adults aged 18 years and older across all 50 states, the District of Columbia, selected local areas, and U.S. territories (72).

Dependent variable

The primary outcome variable assessed was *vaccination behavior*, determined using the NIS-ACM. Participants were asked, "Have you ever received at least one dose of the COVID-19 vaccine?" Response options were "Yes" and "No".

Independent variables

Sociodemographic characteristics. Considered variables included the number of people living in the household, age, gender, county, and the month in which the participant was reached out to by a peer advocate.

Health care providers' recommendations. The NIS-ACM included a question on whether healthcare providers had recommended that the participant get a COVID-19 vaccine. Participants were asked the question, "Has a doctor or nurse, or other health professional ever recommended that you get a COVID-19 vaccine?". Responses assessed ranging from "None" to "Almost all".

Trust in public health agency. Participants were asked their trust levels on public health agency by using one CDC recommended question, "How much do you trust the public health agencies that recommend COVID-19 vaccines?". Participants indicated their level of trust from "Do not trust" to "Fully trust".

Confidence in COVID-19 vaccines. Participants rated their perceived safety and effectiveness of COVID-19 vaccines based on two questions from the NIS-ACM. Safety

was assessed by the question of "How safe do you think a COVID-19 vaccine is for you?". Response options were evaluated from "Not at all safe" to "Completely safe". Effectiveness was assessed by the question of "How effectiveness do you think getting a COVID-19 vaccine is to protect yourself against COVID-19?". Response options were evaluated from "Not at all important" to "Very important". Cronbach's alpha for this measure was 0.8.

Data analysis

Structural equation modeling (SEM) was employed to analyze the mediating role of "confidence in COVID-19 vaccines" on the association between "health care providers' recommendation" and "vaccination behavior", with "trust in public health agency" serving as a moderator. Due to the dichotomous nature of the dependent variable, the weighted least squares mean and variance-adjusted (WLSMV) estimation was utilized to assess the path coefficients within the SEM (146). The model's adequacy was appraised using several fit indices: the root mean square error of approximation (RMSEA), the comparative fit index (CFI), the Tucker-Lewis index (TLI), and the standardized root mean square residual (SRMR), with acceptable thresholds being .90 (adequate) to .95 (good) for CFI and TLI; .05 (good) to .08 (adequate) for RMSEA; and .08 (good) for SRMR. A better fit is indicated by higher CFI and TLI and lower RMSEA and SRMR values. To test the significance of the mediation and moderated mediation effects, bootstrapping was used to obtain confidence intervals for indirect effects. Demographic variables that do not significantly contribute to the model will be excluded stepwise. All statistical analyses were performed using R software (version 4.2.0), applying the 'lavaan' package.

5.4 Results

Table 5.1 Demographic characteristics of participants (n=2,029)

Variables	N (%) or Mean±SD
Age, Mean±SD	42.66 ± 18.71
15-25	505 (24.89%)
26-35	371 (18.28%)
36-45	278 (13.70%)
46-55	255 (12.57%)
56-65	336 (16.56%)
66-75	213 (10.50%)
76-85	53 (2.61%)
86-98	18 (0.89%)
Gender, n (%)	
Male	674 (33.22%)
Female	1347 (66.39%)
Others	8 (0.39%)
Contact date, n (%)	
2021 November	60 (2.96%)
2021 December	77 (3.79%)
2022 January	61 (3.01%)
2022 February	408 (20.11%)
2022 March	263 (12.96%)
2022 April	367 (18.09%)
2022 May	208 (10.25%)
2022 June	151 (7.44%)
2022 July	224 (11.04%)
2022 August	196 (9.66%)
2022 September	14 (0.69%)
Participant's County, n (%)	
Allendale	71 (3.50%)
Bamberg	81 (3.99%)
Barnwell	44 (2.17%)
Beaufort	4 (0.20%)
Calhoun	23 (1.13%)
Cherokee	11 (0.54%)
Chesterfield	98 (4.83%)
Clarendon	56 (2.76%)
Colleton	10 (0.49%)
Darlington	226 (11.14%)
Dillon	15 (0.74%)
Fairfield	13 (0.64%)
Greenville	8 (0.39%)
Hampton	80 (3.94%)
Horry	10 (.049%)
Jasper	9 (0.44%)
Kershaw	4 (0.20%)
Lee	162 (7.98%)
Lexington	78 (3.84%)
Marion	61 (3.01%)
Marlboro	18 (0.89%)
McCormick	24 (1.18%)
Newberry	10 (0.49%)
Orangeburg	284 (14.00%)
Richland	324 (15.97%)
Spartanburg	4 (0.20%)
Sumter	145 (7.15%)
Williamsburg	137 (6.75%)
York	9 (0.44%)
Aiken, Berkeley, Chester, Charleston, Greenwood, Laurens [1]	6 (0.30%)
Edgefield, Florence [2]	4 (0.20%)
Number of people living in household, n (%)	
0 (live alone)	70 (3.45%)
1	537 (26.47%)
2-4	1228 (60.52%)
5-8	194 (9.56%)
COVID-19 infection, n (%)	
Had COVID-19 infection	813 (40.07%)
Never been infected with COVID-19	1216 (59.93%)
Received at least one dose of COVID-19 vaccines, n (%)	
Yes	1612 (74.45%)
No	382 (18.83%)
Don't know	35 (1.72%)

1. One participant came from each county. 2. Two participants came from each county.

Table 5.1 presented an overview of the demographic characteristics of surveyed participants, comprising a total of 2,029 individuals from AA communities. These participants' ages ranged from 15 to 98 years, with a mean age of 42.66 years. Most participants were aged 45 or younger, accounting for 56.87% of total participants. Regarding gender, the survey included 33.22% male participants and 66.39% female participants. The top three counties with the highest number of participants were Richland (15.97%), Orangeburg (14%), and Darlington (11.14%) Counties. The data spanned from November 2021 to September 2022, showing a varied participation rate over this period. Notably, the months of February (20.11%) and April (18.09%) in 2022 received the highest levels of participant engagement. The survey data encompassed information regarding the number of people living in each participant's household. Most participants lived in households with two to four people (60.52%), followed by one person (26.47%), and a smaller percentage lived alone (3.45%). Regarding COVID-19 infection status, approximately 40.07% of the participants reported prior COVID-19 infection, while 59.93% stated never having been infected with the virus. A considerable portion (74.45%) have received at least one dose of COVID-19 vaccines.

Table 5.2 Descriptive statistics of participants

		Total population N=2029	Male N=674	Female N=1347
Age	Mean	42.66	41.45	43.24
	SD	18.71	18.94	18.57
Heath care providers' recommendation	Mean	2.44	2.32 **	2.5 **
	Range	(1,4)	(1,4)	(1,4)
Confidence in COVID-19 vaccines	Mean	5.80	5.68 *	5.86 *
	Range	(2,8)	(2,8)	(2,8)
Trust in public health agency	Mean	2.56	2.5 *	2.59 *
	Range	(1,4)	(1,4)	(1,4)

* t-test $p<.05$; ** t-test $p<.001$

Table 5.2 presents that health care providers' recommendation, confidence in COVID-19 vaccines, and trust in public agency indicate difference impacts between male and female participants. For health care providers' recommendations, females reporting higher levels of vaccination recommendations compare with male participants. For confidence in COVID-19, female participants showed higher level of confidence. For the trust in public health agency, female participants showed slightly higher trust than male participants.

Table 5.3 Effects on vaccination bahavior and confidence in COVID-19 vaccines

		b	se	z	p
Vaccination behavior →					
Health care providers' recommendation	c	0.007	0.007	0.968	<0.01
Confidence in COVID-19 vaccines	b	0.113	0.006	18.860	<0.01
Confidence in COVID-19 vaccines →					
Health care providers' recommendation	a	0.126	0.027	4.744	<0.01
Trust in public health agency	d	0.185	0.032	3.681	<0.01
Age	e	0.010	0.002	6.475	<0.01
Sex	h	0.029	0.059	0.498	0.619

Table 5.3 presented the descriptive statistics regarding the surveyed participants, totalling 2,029 individuals, which included 674 males and 1,347 females. The survey assessed the mean levels of health care providers' recommendation, confidence in COVID-19 vaccines, and trust in public health agencies, all of which demonstrated gender differences. Males reported a mean of 2.32 in health care providers' recommendations, while females reported a higher mean of 2.50, a difference that was statistically significant ($p < .001$). Confidence in COVID-19 vaccines was also higher in females (mean = 5.86) compared to males (mean = 5.68), with statistical significance ($p < .05$). Additionally, trust in public health agencies showed a similar pattern, with females

expressing slightly higher trust (mean = 2.59) than males (mean = 2.50), again with a statistically significant difference ($p < .05$).

Table 5.4 Decomposition of the effects on vaccination behavior

	b	se	z	p
Direct Effect				
Health care providers' recommendations → vaccination behavior	0.007	0.007	0.968	<0.01
Mediation effect				
Health care providers' recommendation → confidence in vaccines → vaccination behavior	0.017	0.009	2.004	<0.01

Table 5.4 reported the decomposition of effects on vaccination behavior, focusing on the influence of health care providers' recommendations and confidence in vaccines. Health care providers' recommendations were associated with vaccination behavior, as evidenced by a statistically significant effect ($b = 0.007$, $p < 0.01$). Confidence in COVID-19 vaccines also significantly influenced vaccination behavior ($b = 0.113$, $p < 0.01$). Furthermore, trust in public health agencies significantly moderated the relationship between health care providers' recommendations and confidence in vaccines ($b = 0.185$, $p < 0.01$). The positive coefficient suggested that higher levels of trust in public health agencies amplified the positive effect of health care providers' recommendations on vaccine confidence.

The fit indices for the model indicated a good fit to the data, with CFI of 0.932, TLI of 0.901, RMSEA of 0.085, and SRMR of 0.043. The CFI and TLI values indicated a good fit, while the RMSEA suggested an acceptable fit, and the SRMR value was within a desirable range for model fit adequacy.

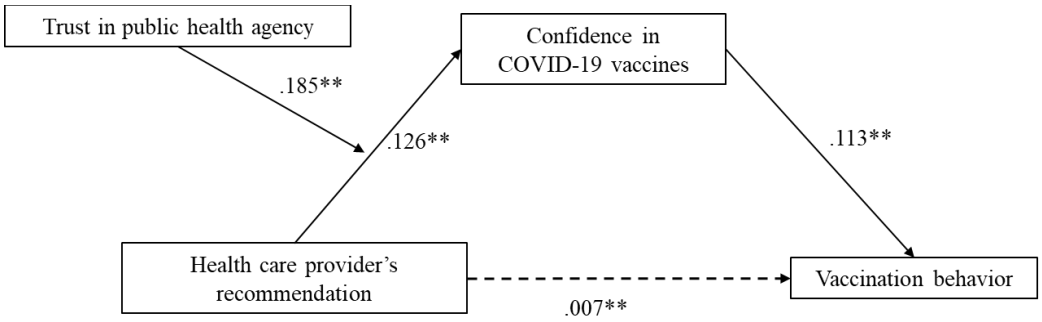

Figure 5.2 Moderated mediation model among health care providers' recommendations and vaccination behavior via confidence in COVID-19 vaccines

Figure 5.2 presented a moderated mediation model, examining the impact of health care providers' recommendation on vaccination behavior and the mediating role of confidence in COVID-19 vaccines, with trust in public health agency serving as a moderator. Results showed that health care providers' recommendation was positively associated with vaccination behavior ($b = 0.007$, $p < .01$). Confidence in COVID-19 vaccines had a positive effect on vaccination behavior ($b = 0.113$, $p < .01$), indicating that as confidence increased, so did the likelihood of engaging in vaccination behavior. Furthermore, trust in the public health agency significantly moderated the effect of health care providers' recommendation on confidence in COVID-19 vaccines ($b = 0.185$, $p < .01$). This interaction suggests that higher trust in a public health agency could strengthen the relationship between health care providers' recommendations and increased confidence in COVID-19 vaccines. The path from health care providers' recommendation to confidence in vaccines was also significant ($b = 0.126$, $p< .01$).

5.5 Discussion

The current study examined the association among health care providers' recommendation, confidence in COVID-19 vaccines, trust in public health agency, and vaccination behavior. Consistent with the hypotheses, confidence in COVID-19 vaccines

was positively associated with health care providers' recommendations and AAs' vaccination behavior. Trust in the public health agency moderated the relationship between health care providers' recommendation and vaccine confidence, indicating that greater levels of trust strengthen the impact of provider recommendations on vaccine confidence.

AAs' vaccination behavior can be affected by health care providers' recommendation. Studies show that receiving information on vaccines from trustworthy health care providers increased AAs' confidence and promote their action to get vaccinated (180). Research has shown that health care providers' recommendations significantly influence vaccination for influenza (flu) and Human Papillomavirus (HPV) vaccines, but the impact was even more obvious with the COVID-19 vaccine, given the urgency associated with the pandemic (181). Studies support our findings that health care providers as a part of social support, their recommendations have greater impacts on vaccination decision making (182, 183). When making decisions about vaccination, people expect to be counseled by someone close to them (e.g., family and friends), or someone they trust (e.g., a health care provider) (184, 185).

Among AA communities, common barriers to COVID-19 vaccination were the quick development and concerns about vaccine safety (121). A study surveyed a nationally representative sample of AA and Whites found that AA participants reported less medical trust than Whites (186). AA respondents also reported feeling less cared for by their physicians than White respondents, which contributes to lower levels of trust (186). In building trust and vaccine confidence among AA communities, local public health departments provide community-based organizations with the expertise and

training in setting up vaccination events, ensuring to reach out to more community members to get vaccinated (187). An increased representation of AA professionals in clinical care to advocates the communities they represent and share their experience with more AA communities.

It is notable to find that female AA participants exhibited higher levels of trust in public health agency and greater confidence in vaccines compared to male participants. Prior studies suggests that men are generally more inclined to trust than women, which makes these findings among AA communities special for several reasons (188, 189). Women engage more actively with health care systems due to various factors, including reproductive health needs (190). This greater engagement might lead to higher levels of health literacy and, consequently, greater trust in health recommendations and confidence in vaccines. In addition, women may also play more roles in their families and communities, acting as key messengers of health information and influencing health decision-making for their families (191). These social networks can be sources of positive reinforcement for trust in healthcare systems and vaccine confidence.

Moreover, studies showed that less trust in the health care system makes AAs more sensitive to misinformation about COVID-19 vaccines (189). A further aspect that emerged concerns the inconsistency and contradictory aspects of the information reported by the health authorities (192). Research showed that addressing low levels of trust in COVID-19 vaccines, vaccination promotion efforts should both involve and be informed by health professionals, including physicians, nurses, pharmacists, community health workers, and mental health therapists, who have ongoing relationships with community members and likely have increased capacity to build trust (188). AAs intends to get

vaccinated have higher trust in information coming from health care providers, the CDC, the WHO, and local public health officials (193). Analyzing the history of distrust of AAs in the health care system, drew attention to this lack of trust (194). Therefore, it requires the medical establishment to demonstrate its trustworthiness in order to begin to mitigate vaccine disparities.

Limitations

Several limitations should be acknowledged in the present study. First, the study utilized self-reported measures, which may cause response bias. Participants' responses may be influenced by social desirability, potentially leading to overestimation of barriers related to COVID-19 vaccination. Second, this study primarily utilized a survey approach to investigate the research hypotheses. While surveys offer valuable quantitative data, they may not capture the full complexity and nuances of the cultural context surrounding COVID-19 vaccination decision-making among AA communities. To obtain a more comprehensive understanding, future research should consider incorporating qualitative studies to gather detailed information and explore the specific experiences and perspectives of AA community members. Third, the survey sample was not representative. Since it is possible that only people interested in vaccination-related topics chose to attend the outreach events and thus were reached by peer advocates.

5.6 Conclusion

The study underscored the importance of health care providers' recommendations in fostering vaccine confidence and subsequent vaccination behavior among AAs. Moreover, it elucidated the enhancing role of trust in public health agencies, suggesting that interventions aimed at increasing vaccine uptake should focus on both improving the

credibility of health care providers and rebuilding trust in public health institutions. Adapting public health strategies to address vaccine hesitancy and increase vaccination rates in AA communities. In addition, to address future public health crises, we need to take a proactive approach to building trust and confidence in the health care system among AA communities. Resources allocated for training can equip health care providers with the skills to communicate effectively about vaccines, addressing specific concerns of AAs and fostering vaccine confidence.

CHAPTER 6

COVID-19 VACCINATION AND RACIAL RESIDENTIAL SEGREGATION: COUNTY LEVEL ANALYSIS OF SOUTH CAROLINA

6.1 Abstract

Background: Health inequities between African Americans (AAs) and Whites have been exacerbated during the COVID-19 pandemic. The disparity in vaccination rates by race/ethnicity further impacts the control and prevention of this infectious disease. Racial residential segregation, one key structural level factor contributing to health disparities, may also affect vaccination uptake among AA populations. This study investigated the relationship between racial residential segregation and the COVID-19 vaccination rates among AAs and Whites across counties in South Carolina (SC).

Methods: Utilizing data from the Centers for Disease Control and Prevention, SC Department of Health and Environmental Control, County Health Rankings, and HD*Pulse*, we compare county-level vaccination rates between AAs and Whites in SC. The residential segregation was measured by the index of dissimilarity (D). By integrating COVID-19 vaccination data with the index of dissimilarity for 46 SC counties, we performed correlation and linear regression analyses to assess the impact of racial residential segregation on vaccination disparities. The correlation and multivariate linear regression analyses was performed in R version 4.1.2.

Results: Among the 46 counties analyzed, 25 counties were identified as the least segregated (D<34), and 21 counties as the most segregated (D≥34). Findings revealed that in the most segregated counties, the full vaccination rate for AAs was 8.41% lower than Whites. In the least segregated counties, the vaccination rate for AAs was 8.76% higher than Whites. Residential segregation was negatively correlated with the percentage of administered vaccine doses (fully vaccinated) for AAs (r=-0.905) and Whites (r=-0.921). Multivariate linear regression analysis reinforced these correlations. Higher residential segregation was significantly and negatively associated with vaccination rates among AAs ($b = -0.6161$, $p < 0.01$). Similar negative associations were found for Whites ($b = -0.7066$, $p < 0.01$). The regression also revealed that an increase in residential segregation was related to a growing disparity in vaccination rates between AAs and Whites ($b = 0.0905$, $p < 0.05$).

Conclusion: The results underscore the importance of considering racial residential segregation when planning and distributing resources for vaccination promotion. By acknowledging and addressing the structural factors, such as segregation, strategies can be more tailored to the communities most in need. This approach could increase vaccination rates among AA populations and improve health care system preparedness for future public health crises.

6.2 Introduction

The COVID-19 pandemic has exacerbated health disparities across racial and ethnic groups in the United States, particularly affecting African American (AA) communities (35, 36). Studies have shown that AAs are nearly three times more likely to get infected with COVID-19 and twice as likely to die from the virus as Whites (37).

Although COVID-19 vaccines have proven to be an effective measure for preventing virus transmission and reducing the risk of severe illness, AAs have shown greater level hesitancy towards vaccination (95). During the pandemic outbreak, AA communities exhibited the most hesitancy regarding future COVID-19 vaccination (92). The higher vaccination hesitancy was indicated by their delayed or refused vaccination behavior (93-96). In January 2021, 52% of AAs had a "wait and see" attitude about getting vaccinated, compared to 40% of Whites (38).

South Carolina (SC) has a population of 5,282,634, about 26.3% were AA, and 68.9% were White (140). SC ranked 15th in the proportion of AA residents in the US, with the majority of AAs residing in the Midlands and Low Country regions of SC (141). As of May 10, 2023, SC reported a total of 1,481,646 COVID-19 cases and 17,869 deaths (142). Through numerous efforts to promote vaccination, 71% of eligible residents (3,666,079 people) have received at least one dose of COVID-19 vaccines, and 60% (3,091,956 people) have been fully vaccinated (143). However, in this evolving context, AAs have been disproportionately affected by COVID-19, exhibiting higher rates of cases, hospitalizations, and deaths compared to their White counterparts (35, 36). Meanwhile, AAs still lag behind Whites in vaccination rates (85). Existing data reveal racial disparities and challenges in responding to the COVID-19 pandemic and promoting vaccination, while also emphasizing the urgency of finding solutions with a focus on the SC region.

Residential segregation is a pronounced manifestation of structural racism and a profound determinant of health disparities, particularly among AA communities (47). Research suggests that residential segregation extends beyond geographic separation of

racial and ethnic minorities (i.e., AAs) from Whites (103, 104). It is an indicator of systemic inequality with broad public health implications (103-105). Segregation has been shown to have a disproportionately negative impact on AAs' health outcomes, affecting their life expectancy and disease prevalence (65). While residential segregation is a fundamental cause of health disparities along racial lines, segregation also affects the accessibility and utilization of health care services (106, 107). Much research shows that segregation exacerbates disparities not just in health but also in access to employment and essential services, often requiring people in segregated areas to travel greater distances for employment and childcare, thereby hindering their access to essential services and further perpetuating health inequities (107, 108).

To gain an understanding of how structural level factor (e.g., residential segregation) affect vaccination rates among AA and White populations. This study aimed to investigate the relationship between residential segregation and COVID-19 vaccination rates among AAs and Whites across counties in SC.

6.3 Methods

Data sources

Data were sourced from four publicly available datasets. COVID-19 vaccination rates were extracted from the CDC COVID-19 Vaccinations in the United States, County and the SC Department of Health and Environmental Control (SCDHEC) COVID-19 Vaccination Dashboard (147, 148). The vaccination data was from September 23, 2021, one month after the U.S. Food and Drug Administration granted full approval to the Pfizer-BioNTech vaccine for individuals aged 16 and older (195). These vaccination rates represent the percentage of the county population documented as fully vaccinated.

Structural level data were extracted from the 2020 County Health Rankings, the HD*Pulse*: An Ecosystem of Minority Health and Health Disparities Resources, and the 2021 American Community Survey (81, 151, 152).

Key measures

Outcome variable

Percent of AA or White population ages 18 years and older who have completed a primary series. This rate calculated the percentage of the adult population (aged 18 and older) within AA or White groups that had completed the primary series of COVID-19 vaccination. This included individuals who had received the second dose of a two-dose vaccine or a single dose of a one-dose vaccine, again based on the jurisdiction and county where the vaccine recipient resided. This metric was essential for assessing the completion of the vaccination series, which is critical for full vaccination protection.

AA-White vaccination difference (fully vaccinated). This measure focused on the difference in vaccination rates between AA and White populations, specifically regarding the completion of the primary vaccination series. The vaccination difference was calculated by subtracting Whites' vaccination rates from AAs' vaccination rates.

Independent variables

Residential segregation – AA/White. The data was assessed from the HD*Pulse*: An Ecosystem of Minority Health and Health Disparities Resources and the 2020 County Health Rankings (81, 152). Racial residential segregation refers to the degree to which two or more groups live separately from one another in a geographic area. It is measured using an index of dissimilarity (D). The index of dissimilarity measures the percentage of a group's population that would have to change residence for each neighborhood to have

the same percentage of that group as the metropolitan area overall. The index of dissimilarity measures how two groups (i.e., AA and White residents) are distributed across census tracts that make up the county. The residential segregation index rages from 0 (complete integration) to 100 (complete segregation). The higher values of the index of dissimilarity indicate greater residential segregation between AA and White residents. Moreover, the cut-off point of levels of residential segregation was 34 due to the highly skewed distribution of the data. Key variables were compared between the most segregated ($D \geq 34$) and the least segregated ($D < 34$) counties.

Social association rate. The social association rate was derived from the publicly available data of the 2020 County Health Rankings database (152). The social association rate is a metric to assess social or community support at the county level. The rate measures the number of membership associations per 10,000 population. The numerator is the total number of membership associations in a county, while the total population of a county forms the denominator of this measure. The term "membership association" comprises membership in fitness centers, bowling centers, golf clubs, and civic, sports, religious, political, labor, business, or professional organizations.

Household crowding (households with >1 person per room). The data of AA and White populations was derived from the HD*Pulse*: An Ecosystem of Minority Health and Health Disparities Resources and the 2021 American Community Survey (ACS) (81, 151). A housing unit is often considered crowded if it has more than one person to a room. The number of persons per room is calculated for a household by dividing the number of occupants by the number of rooms.

Education. The data of AA and White populations was derived from the HD*Pulse*: An Ecosystem of Minority Health and Health Disparities Resources and the 2021 American Community Survey (81, 151). Persons with a bachelor's degree or higher are those who have received a bachelor's degree from a college or university, or a master's, professional, or doctorate degree. Data includes only people 25 years old and over. The percentages are obtained by dividing the counts of graduates by the total number of persons 25 years old and over.

Data analysis

Among the 46 counties analyzed, 25 counties were identified as the least segregated ($D<34$), and 21 counties as the most segregated ($D\geq34$). A correlation analysis was first conducted to assess the strength and direction of the relationship between residential segregation, social association rate, household crowding, education, and COVID-19 vaccination rates in AA and White populations. Following the correlation analysis, a linear regression modeling was performed to identify significant structural level factors influencing vaccination rates. All analyses were conducted in R version 4.1.2.

6.4 Results

Table 6.1 Descriptive statistics (n=46)

Variables	Mean	Min	Max
Residential segregation	35.3	14	57
Social association rate	11.64%	5.6%	18.1%
Household crowding (AA)	2.81	0.5	7.7
Household crowding (White)	1.55	0	3.4
Education (AA)	13.47%	5.8%	27.9%
Education (White)	26.14%	8.5%	57.4%
Percent of 18+ AA (fully vaccinated)	40.73%	25.8%	55.4%
Percent of 18+ White (fully vaccinated)	49.15%	31.7%	64.5%
AA-White vaccination difference (fully vaccinated)	-8.41%	-3.5%	-12.7%

In a sample of 46 SC counties, descriptive statistics revealed differences in crowding, education, and COVID-19 vaccination rates between AA and White populations (Table 6.1). The mean residential segregation, as indicated by the index of dissimilarity, stood at 35.3. AAs experienced more household crowding, averaging 2.81 individuals per room, whereas White households had an average of 1.55 individuals per room. There was a difference in educational attainment, where AAs have a lower percentage of college-educated individuals at 13.47%, compare 26.14% for Whites. Regarding vaccination, the data indicated that AAs have a lower mean percentage of fully vaccinated individuals over 18 (40.73%) compared to Whites (49.15%). The gap between the vaccination rates of the two groups was further counted, with an average difference of -8.41%, where AAs are less vaccinated compared to Whites across the counties analyzed.

Table 6.2 Mean values for the most and least segregated counties (n=46)

Variables	Mean All counties	Most segregated (n=21)	Least segregated (n=26)
Residential segregation	35.3	42.48	26.76
Social association rate	11.64	12.41	10.72
Crowding AA	2.81	2.44	3.25
Crowding White	1.55	1.44	1.69
Education AA	13.47%	15.80%	10.69%
Education White	26.14%	29.81%	21.77%
Percent of 18+ AA (fully vaccinated)	40.73%	36.62%	45.62%
Percent of 18+ White (fully vaccinated)	49.15%	44.74%	54.39%
AA-White vaccination difference (fully vaccinated)	-8.41%	-8.12%	-8.76%

The mean values presented in Table 6.2 for the 46 counties demonstrated differences between the most and least segregated counties. AAs faced higher crowding rates in the least segregated counties, while the most segregated counties reported higher levels of college education among AAs. The data also showed that the most segregated counties had a full vaccination rate for AAs that was 8.41% lower than that of Whites, whereas in the least segregated counties, AAs were vaccinated at a rate 8.76% lower than Whites.

Table 6.3 Correlation matrix (n=46)

		1	2	3	4	5	6	9	10
1	residential segregation	1							
2	social association rate	0.356	1						
3	household crowding (White)	-0.170	0.066	1					
4	household crowding (AA)	-0.355	-0.345	0.237	1				
5	percent of college education (white)	0.548	0.018	-0.359	-0.317	1			
6	percent of college education (AA)	0.459	-0.152	-0.129	-0.152	0.607	1		
9	percent of full vaccination (AA)	-0.905**	-0.335	0.120	0.307	-0.531	-0.384	1	
10	percent of full vaccination (White)	-0.921**	-0.368	0.119	0.358	-0.498	-0.374	0.963	1

*p<.05; **p<.001

In the correlation matrix presented in Table 6.3 for a sample size of 46 counties, the variable of residential segregation demonstrated a positive correlation with the social association rate (r = 0.356). This result suggests that areas with higher levels of segregation tend to also have a higher number of social associations. Residential segregation exhibited a negative association with the percent of household size per room for both White (r = -0.170) and AA populations (r = -0.355), suggesting that higher segregation was linked to less crowding in homes for both demographic groups.

Moreover, residential segregation was positively correlated with the percentage of college education among both Whites (r = 0.548) and AAs (r = 0.459). This indicates that in areas with higher segregation, there were also higher levels of college education attainment within these racial groups. Furthermore, a strong negative correlation was observed between residential segregation and the percentage of administered vaccine doses, for completing the vaccine series, for AAs (r = -0.905) and Whites (r = -0.921).

These correlations suggest that higher levels of segregation were associated with lower vaccination rates in both AAs and Whites.

Table 6.4 Multivariate linear regression for three dependent variables (n=46)

Fully vaccinated (AA)							
variable	**b**	**se**	**t**	**P>|t|**	**CI lower**	**CI upper**	**R^2**
(constant)	64.3854	3.307	19.469	0	57.696	71.074	82.90%
residential segregation	-0.6161	0.063	-9.766	0	-0.744	-0.489	
social association rate	-0.0114	0.188	-0.061	0.952	-0.391	0.368	
household crowding (AA)	-0.1173	0.365	-0.322	0.749	-0.855	0.621	
household crowding (White)	-0.5142	0.64	-0.804	0.426	-1.808	0.78	
bachelor or above education (AA)	0.1167	0.119	0.985	0.331	-0.123	0.356	
bachelor or above education (White)	-0.0846	0.067	-1.271	0.211	-0.219	0.05	
Fully vaccinated (White)							
variable	**b**	**se**	**t**	**P>|t|**	**CI lower**	**CI upper**	**R^2**
(constant)	74.1732	3.407	21.771	0	67.282	81.065	85.40%
residential segregation	-0.7066	0.065	-10.872	0	-0.838	-0.575	
social association rate	-0.0314	0.193	-0.162	0.872	-0.422	0.359	
household crowding (AA)	0.1911	0.376	0.508	0.614	-0.569	0.951	
household crowding (White)	-0.5086	0.659	-0.772	0.445	-1.842	0.824	
bachelor or above education (AA)	0.1057	0.122	0.866	0.392	-0.141	0.353	
bachelor or above education (White)	-0.0339	0.069	-0.495	0.624	-0.173	0.105	
Fully vaccinate (AA-White difference)							
variable	**b**	**se**	**t**	**P>|t|**	**CI lower**	**CI upper**	**R^2**
(constant)	-9.7878	2.19	-4.469	0	-14.217	-5.358	21.90%
residential segregation	0.0905	0.042	2.166	0.036	0.006	0.175	
social association rate	0.0199	0.124	0.161	0.873	-0.231	0.271	
household crowding (AA)	-0.3084	0.242	-1.276	0.209	-0.797	0.18	
household crowding (White)	-0.0056	0.424	-0.013	0.989	-0.862	0.851	
bachelor or above education (AA)	0.011	0.078	0.14	0.889	-0.148	0.17	
bachelor or above education (White)	-0.0507	0.044	-1.149	0.257	-0.14	0.038	

The multivariate linear regression analysis that was reported in Table 6.4 examined the determinants of full vaccination rates among AAs, Whites, and the difference between these two groups, with the analysis encompassing 46 SC counties. For the full vaccination rates among AAs, there was a significant negative association with residential segregation ($b = -0.6161$, $p < 0.01$), suggesting that higher levels of residential segregation were associated with lower vaccination rates in fully vaccinated AA

populations. Social association rate, crowding (household size), and education were not significant associated with the full vaccination rates among AAs.

For the full vaccination rates among Whites, there was a significant negative association between residential segregation ($\beta = -0.7066$, $p < 0.01$). This negative association paralleled the pattern noted within AAs. Social association rate, crowding (household size), and education were not significant associated with the full vaccination rates among Whites.

When examining the differences in full vaccination rates between AAs and Whites, there was a significant positive association between residential segregation ($\beta = 0.0905$, $p = 0.036$), indicating that as residential segregation increased, the disparity in vaccination rates between AAs and Whites widened. Other variables did not significantly predict the difference in vaccination rates between AAs and Whites.

6.5 Discussion

This study investigated the relationship between residential segregation and COVID-19 vaccination in SC counties. The results highlight that residential segregation emerged as a prominent factor negatively impacting full vaccination rates for both AA and White populations. Higher levels of residential segregation were associated with lower vaccination rates among AAs and Whites. Differences in vaccination rates between AAs and Whites were found to increase with greater residential segregation.

In this study, the findings showed disparities in vaccination rates between AAs and Whites. Our findings are consistent with prior research indicating a higher level of vaccination hesitancy among AAs (159, 196). The significance of structural factors in uncovering the underlying causes of such disparities is increasingly recognized (197).

Several studies have suggested that residential segregation is a fundamental cause of health disparities in AA and White population, affecting health outcomes through multiple pathways such as access to care, environmental exposure, socioeconomic status, and social capital (198, 199). Incorporating the findings of this study, the negative association between residential segregation and vaccination rates reveals a phenomenon in which counties that are segregated may lack health care facilities and have fewer health care providers per capita, leading to decreased access to health care services including vaccinations (200). These findings suggested that public health interventions need to specifically target and address structural barriers, with an emphasis on prioritizing resources to the most segregated counties to enhance health care equity.

The study findings support previous research on social determinants of health regarding the non-significant impact of social association rate, household size, and education on vaccination rates (201). Although these factors are acknowledged as influential to overall health outcomes, they may not be as immediately influential on vaccination behaviors as the direct barriers imposed by residential segregation. This implies that interventions to improve vaccination rates need to directly target the barriers imposed by segregation, rather than solely focusing on social and educational improvements. In SC, public health campaigns and outreach have achieved success; however, AA residents continue to be significantly underrepresented among those vaccinated (39, 202).

The positive association between residential segregation and racial disparities in vaccination rates is also in concordance with literature that more segregated areas typically experience more significant health disparities (203). In SC, the long history of

residential segregation faced by AAs contributes significantly to health disparities (204). This phenomenon is not unique to SC but is a common challenge in many U.S. states (128). These health disparities are reflected not only in higher rates of disease, but also in higher mortality rates (205, 206). They are often associated with multiple disadvantages such as poorer housing conditions, limited access to quality educational resources and employment opportunities, and difficulties in accessing health care resources (37, 206). Therefore, there is a need to promote collaboration between different fields, such as public health, urban planning, education, and economic development, to address the broader health impacts of residential segregation.

Higher levels of residential segregation were found to correlate with increased rates of social association, indicating a complex relationship with dual aspects of influence. While on one hand, increased social participation within segregated counties may reflect a strengthening of social bonds and networks, it also points to the possibility that such segregation intensifies reliance on local social structures due to limited access to broader societal resources. Individuals with stronger social connections are more likely to adopt health-promoting behaviors and experience better health outcomes (207, 208). The presence of robust community networks, such as neighborhood groups, may build social cohesion and facilitate collective actions that contribute to improved health in segregated neighborhoods (209, 210). The findings highlight the need of launching transparent COVID-19 vaccination campaigns and interventions grounded in research findings and cultural humility and delivered by trusted messengers. Local communities should be involved in these initiatives and collaborate with researchers and governments to make decisions about public health messaging and strategies that are tailored to their

needs. Further research is necessary to evaluate the impact of public health interventions on vaccine uptake and on successful community-engaged research and practice. Future research should aim to improve our understanding of how structural factors impact COVID-19 vaccination rates. Additionally, interventions should be designed to address residential segregation in COVID-19 vaccination, especially in medically and socially vulnerable populations.

Limitations

Some limitations of the current study need to be acknowledged. First, the geographical focus on SC may limit the generalizability of the findings to other regions with different social, economic, and health dynamics. Second, the study did not account for all possible confounding variables that might influence vaccination behavior, such as socioeconomic status or access to health care. Third, the analyses focused on the county level due to data availability. Future research needs to examine the relationships in a more granular geographic unit (e.g., zip code level) because there are important variations in residential segregation and community health within each county.

6.6 Conclusion

The study underscored the importance of considering racial residential segregation when planning and distributing resources for vaccination promotion. Residential segregation and its impact on health care access and outcomes necessitates a strategic approach that specifically targets the structural barriers impeding vaccination. Tailored strategies that account for the unique challenges faced by communities shaped by segregation could substantially enhance the effectiveness of vaccination campaigns, ultimately leading to higher vaccination rates within AA populations. Recognizing and

actively addressing these structural factors are essential steps towards equity in public health. Interventions must not only distribute resources equitably but also deliver them through culturally competent, accessible, and trusted channels within segregated communities. In addition to increasing current vaccination rates, these efforts could serve to build a more resilient health care system, one that is better prepared to respond to future public health crises with agility and sensitivity to the needs of all community members.

CHAPTER 7

DISCUSSION

7.1 Summary of the dissertation

The dissertation was developed to examined intrapersonal, interpersonal, and structural level factors affecting vaccination behavior among AAs in SC. The first study aimed to examine the effects of perceived barriers to vaccination and AAs' confidence in COVID-19 vaccines on their actual vaccination behavior. The study findings indicated that AAs' confidence in COVID-19 vaccines was negatively associated with perceived barriers to vaccination, and positively associated with vaccination behavior. AAs' confidence in COVID-19 vaccines mediated the association between their perceived barriers to vaccination and vaccination behavior. Information seeking about COVID-19 vaccines served as a moderator in the relationship between perceived barriers to vaccination and confidence in COVID-19 vaccines. The second study assessed the extent to which confidence in COVID-19 vaccines mediated the association between health care providers' recommendations and vaccination behavior among AA communities. The study findings demonstrated that AAs' confidence in COVID-19 vaccines mediated the relationship between health care providers' recommendations and AAs' vaccination behavior. Moreover, AAs' trust in the public health agency moderated the relationship between health care providers' recommendations and AAs' confidence in vaccines, indicating that higher trust levels strengthened the impact of health care providers'

recommendations on vaccine confidence. The third study further investigated structural level factors affecting COVID-19 vaccination rates among AAs and Whites. Utilizing population level datasets, the results showed that residential segregation significantly and negatively impacted full vaccination rates for both AA and White populations. Higher levels of residential segregation were associated with lower vaccination rates, and differences between the two groups' vaccination rates widened with increasing residential segregation.

7.2 Limitations

Although the dissertation study aimed to provide innovative insights into the factors influencing COVID-19 vaccination, there are several potential limitations that need to be considered when interpreting the findings and implications of the study. First, the study utilized self-reported measures, which may cause response bias. Participants' responses may be influenced by social desirability, potentially leading to overestimation of barriers related to COVID-19 vaccination. Second, this study primarily utilized a survey approach to investigate the research hypotheses. While surveys offer valuable quantitative data, they may not capture the full complexity and nuances of the cultural context surrounding COVID-19 vaccination decision-making among AA communities. To obtain a more comprehensive understanding, future research should consider incorporating qualitative studies to gather detailed information and explore the specific experiences and perspectives of AA community members. Third, the survey sample was not representative. Since it is possible that only people interested in vaccination-related topics chose to attend the outreach events and thus were reached by peer advocates. In addition, we did not recruit participants across counties based on the proportion of the

AA population in the counties. Fourth, I use county level data from SC but it is not obvious that the same relationship between racial residential segregation and vaccination rates would hold in other states. Fifth, I only consider AA and Whites differences, and I recognize that there are other racial and ethnic groups where research need to focus on to address their challenges and promote vaccination.

7.3 Implications

7.3.1 Research implication

The dissertation has implications for COVID-19 vaccination-related research. First, this exploration of multilevel factors influencing COVID-19 vaccination among AA communities contributes to a broader understanding of vaccination behavior within underserved populations. By revealing the complex interplay between intrapersonal, interpersonal, and structural level factors that affect vaccination, this dissertation provides a foundation for future investigations seeking to untangle similar complexities across diverse socio-demographic groups and geographic regions. Second, the dissertation's focus on AA communities directly addresses health disparities. The findings can offer insights into the underlying causes of vaccine hesitancy, mistrust, and barriers to vaccinations within AA communities. This knowledge is essential for health care policymakers, practitioners, and researchers committed to reducing health disparities and ensuring equitable vaccine distribution and uptake. Third, the identification of barriers and facilitators at different levels of influence can equip researchers to develop targeted and culturally tailored interventions. Future studies can build upon this foundation to further enhance vaccine acceptance and mitigate disparities during pandemics.

7.3.2 Practical implication

Study findings have practical implications in various tiers to mitigate the negative impact of COVID-19 and advance vaccination efforts. First, the emphasis on culturally tailored health communication strategies underscores the need for clear and culturally sensitive communication strategies to disseminate accurate vaccine information. Communication materials and campaigns can be designed to resonate with the cultural norms and values of AA communities, thereby increasing the effectiveness of health messages. Second, by promoting the engagement of community stakeholders and trusted messengers, the study highlights the importance of building collaborative bridges. Collaborative partnerships with local community organizations, leaders, and influencers become essential avenues for accurate information dissemination. This collaborative approach not only counters misinformation but also builds trust. By involving these influential voices, practitioners can cultivate a shared responsibility for public health and foster community-wide engagement. The insights from this dissertation guide the creation of a web of trust, promoting vaccination through local connections and collaborative efforts. Third, the insights gained from the study guide health care providers in navigating complexity with empathy. Informed dialogues, personalized recommendations, and a comprehensive approach to addressing concerns become imperative. By providing a platform for open conversations and informed choices, health care providers can play a significant role in building confidence in vaccines. This approach bridges the gap between AAs' concerns and accurate information, fostering an environment of trust and informed decision-making.

7.4 Future directions and conclusion

Health disparities in the United States have persisted over time, with AA communities facing some of the most adverse outcomes. The outbreak of the COVID-19 pandemic in March 2020 exacerbated these disparities, placing AAs at a significantly higher risk of exposure, severe illness, and mortality. Consequently, as vaccines became available, prioritizing access to vaccination for this disproportionately affected population was important as vaccines became available. Although there was an urgent need, initial vaccination rates within AA communities were notably low. This discrepancy highlights the significance of exploring the factors influencing AA vaccination behaviors, to inform and improve public health communication strategies. This dissertation has bridged insights from the persuasion literature with a comprehensive analysis of the multifactorial influences on vaccination. The findings indicate that vaccination behaviors among AAs are significantly influenced by perceived barriers to vaccination, confidence in COVID-19 vaccines, trust in public health agencies, and health care providers' recommendations. Furthermore, this study has identified disparities in vaccination rates between AA and White populations within the most segregated counties of SC, highlighting the interplay between racial residential segregation and health behaviors.

Although the intentions to vaccination have increased in AA communities over time, the ongoing disparities in SC even in the United States suggest the need for more strategic allocation of public health interventions and resources, especially in highly segregated communities. This dissertation demonstrates the need for collaborative approaches that engage communities in identifying their priorities. Considering the importance of disease prevention efforts and preparation for future public health

emergencies, public officials need to address issues related to confidence and access. Through the data collection process of the COVID-19 vaccination promotion project, trust is always a big challenge for increasing vaccine confidence and demand among AA communities. Community health workers can work as a bridge between the AA communities and the local health system. Community health workers are trusted messengers in their communities and navigators of health care systems and community resources. Benefited from the community-engagement strategies and tailored and appropriate training, community health workers can be empowered and play a critical role in disseminating accurate vaccination information, addressing resource accessing issues and promoting vaccination among their communities. Their high resilience and enthusiasm in helping their communities should be sufficiently recognized and leveraged in response to public health emergencies and sustainable efforts to combat health disparities.

Moreover, this study supports the growing discussion on the importance of analyzing the underlying causes of health disparities. Research and policy initiatives must converge to address the underlying causes of health disparities. Future research should thoroughly investigate the unique characteristics of unvaccinated AA individuals. Understanding these differentiating attributes is crucial for crafting more nuanced and effective vaccination campaigns. Such targeted research will inform the development of interventions that not only reduce disparities in vaccination rates, but also help eliminate racial and ethnic health disparities. This dissertation emphasizes the need for a thorough understanding of the variables that affect health disparities. It promotes the development

of customized, evidence-based public health interventions that are culturally sensitive and responsive to the specific needs of AA communities.

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APPENDIX A: SURVEY QUESTIONNAIRE

Question Order	Questions	Response Options
1	Contact Date:	--
2	Has this person been contacted previously?	No, this is the initial contact (1), Yes, this is a follow-up (2)
3	How many people are living with you right now?	--
4	How old are you?	--
5	Gender:	Male (1), Female (2), Other (3)
6	Have you ever received at least one dose of the COVID-19 vaccine?	Yes (1), No (2), Don't know (3), Refused (4)
7	To your knowledge, have you ever had COVID-19?	Yes (1), No (2)
8	How concerned are you about getting COVID-19?	Not at all concerned (1), A little concerned (2), Moderately concerned (3), Very concerned (4)
9	How safe do you think a COVID-19 vaccine is for you?	Not at all safe (1), Somewhat safe (2), Very safe (3), Completely safe (4)
10	How important do you think getting a COVID-19 vaccine is to protect yourself against COVID-19?	Not at all important (1), A little important (2), Somewhat important (3), Very important (4)
11	In the past month, how often have you tried to find information about COVID-19 vaccines?	Never (1), Rarely (2), Sometimes (3), Often (4)
12	In the last month, have you seen or heard any negative information about the safety or effectiveness of COVID-19 vaccines?	Yes (1), No (2), Not sure (3)
13	How much do you trust the public health agencies that recommend COVID-19 vaccines?	Do not trust (1), Somewhat trust (2), Mostly trust (3), Fully Trust (4)
14	If you had to guess, about how many of your family and friends have received a COVID-19 vaccine?	None (1), Some (2), Many (3), Almost all (4)
15	Has a doctor or nurse, or other health professional ever recommended that you get a COVID-19 vaccine?	None (1), Some (2), Many (3), Almost all (4)
16	Does your work or school require you to get a COVID-19 vaccine?	Yes (1), No (2), Unemployed/Not Applicable (3)
17	How difficult was it for you/would it be for you to get a COVID-19 vaccine?	Not at all difficult (1), A little difficult (2), Somewhat difficult (3), Very difficult (4)

18	Does/did getting an appointment online make it difficult for you to get vaccinated?	Yes (1), No (2)
19	Does/did not knowing where to get vaccinated make it difficult for you to get vaccinated?	Yes (1), No (2)
20	Does/did hard to get to vaccination sites make it difficult for you to get vaccinated?	Yes (1), No (2)
21	Does/did vaccination sites not being open at convenient times make it difficult for you to get vaccinated?	Yes (1), No (2)
22	Does/did the vaccine not being available to get from my preferred healthcare provider make it difficult for you to get vaccinated?	Yes (1), No (2)
23	Was this person referred to a vaccine navigator?	Yes (1), No (2)
24	Was this person referred to any other resources for vaccine uptake?	Yes (1), No (2)
25	What county is this person from?	Abbeville (5), Aiken (6), Allendale (7), Anderson (8), Bamberg (9), Barnwell (10), Beaufort (11), Berkeley (12), Calhoun (13), Charleston (14), Cherokee (15), Chester (16), Chesterfield (17), Clarendon (18), Colleton (19), Darlington (20), Dillon (21), Dorchester (22), Edgefield (23), Fairfield (24), Florence (25), Georgetown (26), Greenville (27), Greenwood (28), Hampton (29), Horry (30), Jasper (31), Kershaw (32), Lancaster (33), Laurens (34), Lee (35), Lexington (36), Marion (37), Marlboro (38), McCormick (39), Newberry (40), Oconee (41), Orangeburg (42), Pickens (43), Richland (44), Saluda (45), Spartanburg (46), Sumter (47), Union (48), Williamsburg (49), York (50)
26	Have you taken the Covid-19 vaccine booster?	Yes (1), No (2)
27	Are you planning to take the Covid 19 vaccine booster annually if offered?	Yes (1), No (2), I don't know (3)