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The Association between Pelvic Floor Dysfunction and Mental Health in Natal Females with a Focus on Native American Populations

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Chapter 1

Pelvic floor dysfunction is an umbrella term for a host of disorders, including overactive bladder, urinary incontinence, pelvic pain, and nocturia. In 2010, an estimated 28.1 million women in the United States suffered from pelvic floor dysfunction and, it is estimated, by 2050 this number will increase to 43.8 million women (Wu et al., 2009). Due to the high prevalence of this disorder, direct and indirect costs are estimated in excess of $60 billion annually in the United States alone (and are projected to exceed $80 billion within the next few years) (Coyne et al., 2014). Direct costs include appointments with urologists, surgical procedures to improve the symptoms of pelvic floor dysfunction, and feminine hygiene products such as pads; however, it is important to note that pelvic floor dysfunction has been associated with higher rates of anxiety and depression in women who experience it, and these direct costs do not account for the additional costs related to the mental health consequences of this condition (Ward-Smith, 2009). Consequences of pelvic floor dysfunction are not limited to health and economic issues, but also have a significant impact on the social lives of those affected (Yip et al., 2013). Due to the stigma and embarrassment surrounding some of the symptoms of pelvic floor dysfunction, many women with the disorder become isolated from friends and family and may no longer partake in activities that they once enjoyed (Yip et al., 2013). The numerous social, economic, and health ramifications associated with pelvic floor dysfunction have made clear that this is not simply a women's health issue, but is, at its core, a public health issue (Reynolds et al., 2016).

Pelvic floor dysfunction is often preventable or treatable; however, rates of treatment-seeking for pelvic floor and its consequences are low, with as few as one-

quarter of women discussing their symptoms with their healthcare provider (Lukacz et al., 2017). A myriad of issues contributes to women choosing not to seek care, and include shame, embarrassment, and feeling that symptoms, such as urinary incontinence, are a normal part of life (Toye & Barker, 2020). Even those who do seek care may never be referred to a specialist who can offer extensive preventive guidance and more advanced treatment options (Lukacz et al., 2017). Because pelvic floor dysfunction is preventable in many cases, providers must be aware of risk factors that can contribute to the development of this condition, including obesity, smoking, parity, and diabetes (Møller et al., 2000; Kawahara et al., 2020). By identifying these risks, as well as early onset pelvic floor dysfunction, the development or severity of the disorder can be mitigated or decreased through provider-guided interventions (U.S. Department of Health & Human Services, 2021).

While most research examining the prevalence of pelvic floor dysfunction has focused on men or White women, one study does note that Hispanic women experience the highest rates of urinary incontinence while Chinese women have the lowest rates (Akbar et al., 2021). There is a paucity of research examining why these disparities in prevalence exist between racial groups. Furthermore, racial disparities in the prevalence of pelvic floor dysfunction have not been studied in Native American women, despite this population of women experiencing risk factors for this disorder at higher rates than women of other races (American Psychological Association, 2015; Sandefur et al., 1996; Centers for Disease Control, 2019). Understanding how pelvic floor dysfunction can impact different groups uniquely is important to developing effective prevention and treatment approaches that are culturally responsive to the needs of all patients.

Quality of life for the Native American population is poor and, making matters worse, longevity for this population is the lowest of any racial group in the US (Poltavski et al., 2010; Dankovchik et al., 2015). Diminished quality of life in Native Americans is largely related to elevated rates of certain health conditions that contribute to poor quality of life, such as obesity, diabetes, and poor mental health (Poltavski et al., 2010). Native American women have been historically underserved and understudied for all physical and mental health outcomes (Smith, n.d.). Furthermore, Native Americans have also suffered abuse, including human rights violations, at the hands of medical practitioners and researchers in the past leading to a reluctance to participate in medical research (Hodge, 2012). Poor access to healthcare and a lack of culturally relevant research, combined with poor access to culturally competent care, has created a hostile landscape for Native American women seeking evaluation and treatment for conditions such as pelvic floor dysfunction (Ely, 2018; Zabat, 2020). Therefore, understanding the risk factors and consequences of pelvic floor dysfunction in this specific population is essential to develop culturally competent treatment and prevention methods with an end goal of improving their overall quality of life.

Aims and Objectives

The literature largely agrees that there is a correlation between pelvic floor dysfunction and mental health struggles, specifically anxiety and depression (Lai et al., 2016). Native American women have higher rates of known risk factors for pelvic floor dysfunction, including obesity, diabetes mellitus, smoking, and increased parity when compared with women of other races (Møller et al., 2000; Kawahara et al., 2020). Furthermore, The Native American population has the highest rate of mental health

struggles and suicide when compared to other races (CDC, 2019; Office of Minority Health, 2020). However, due to Native American preference for utilizing holistic or spiritual caregivers, and a lack of research examining specific mental health disparities in this population, it is difficult, if not impossible, to accurately determine the exact prevalence of anxiety and depression in this population (Mental Health America, 2023). Therefore, it is imperative to determine their relative risk of developing any of the consequences of pelvic floor dysfunction in an effort to mitigate the subsequent anxiety and depression that many women with the condition experience. This information has the potential to guide providers in preventing, diagnosing, and treating pelvic floor dysfunction in this population, thus improving the overall quality of life in Native American women with this condition. The overall objective of this dissertation is to evaluate the association between pelvic floor dysfunction and mental health in the general population of natal females and to subsequently perform a risk analysis, through the use of unsupervised machine learning, to determine the likelihood of developing a consequence of pelvic floor dysfunction in Native American natal females.

Methods

Method for Manuscript 1

A review of the literature was conducted using CINAHL, EBSCOhost, and PubMed to identify articles discussing the prevalence of overactive bladder, risk factors for overactive bladder, and its impact on mental health, specifically as it relates to anxiety and depression using the Boolean operators AND and OR as described in Chapter Two below. Inclusion criteria initially consisted of articles published between 2016 – 2022; however, due to a dearth of literature on the topic the search was expanded to articles

published between 2012 – 2022 to ensure a comprehensive review of the literature. Other inclusion criteria consisted of articles that were written in or translated to the English language. Exclusion criteria included current pregnancy, pediatric populations, and male-only populations. A secondary search of all literature identified was completed to identify any research focused on the Native American population, specifically. Literature was reviewed to examine the direct and indirect relationships between depression, anxiety, and overactive bladder. Tables to report findings are presented.

Method for Manuscript 2

Following the literature review portion of Manuscript 1, the articles identified will be further investigated to examine a) the relationships between risk factors for pelvic floor dysfunction, b) relationships between risk factors and pelvic floor dysfunction, and c) the relationship between pelvic floor dysfunction and mental health (i.e. depression, anxiety), and d) the relationship between mental health and quality of life to build a theoretical model. Unique relationships between risk factors for pelvic floor dysfunction are reported to construct the theoretical model to define the relationship between access to healthcare and quality of life and identification of potential places of intervention to prevent and/or treat pelvic floor dysfunction and the resulting anxiety and depression.

Method for Manuscript 3

The third manuscript utilized secondary data from the Centers for Disease Control and Prevention's Behavioral Risk Factor Surveillance System (BRFSS) to develop a risk prediction model demonstrating the risk of Native American women developing overactive bladder. The risk prediction model was created through the

utilization of unsupervised machine learning. More detailed methodology is described in Chapter Four.

Connections between the Manuscripts

Study one reviewed literature focused on overactive bladder and its connection to anxiety and depression, paying particular attention to Native American women. Study two applied that literature to the construction of a theoretical model illustrating how factors linked to poor access to healthcare may increase the risk of developing pelvic floor dysfunction, subsequent mental health diagnoses and, ultimately, a decreased quality of life. Finally, manuscript three applied the theoretical model to secondary data analysis to predict the risk of overactive bladder in a sample of Native American women.

Overview of Manuscripts

Research Questions and Hypotheses

The overall purpose of this research and series of three manuscripts was to better understand the risk factors and mental health consequences of pelvic floor dysfunction with a particular focus on Native American women. Specifically, these studies have evaluated the association between pelvic floor dysfunction and mental health in the general population of natal females and subsequently performed a risk analysis through the use of unsupervised machine learning to determine the likelihood of Native American women developing a consequence of pelvic floor dysfunction.

Manuscript 1

***Aim*:**

- Is overactive bladder in women associated with higher rates of mental health struggles, specifically anxiety and depression?

- Should there be a recommendation to screen all women with overactive bladder for anxiety and depression?
- Is there currently literature and/or data that examines overactive bladder and/or its mental health consequences in Native American women?

Hypotheses

Overactive bladder will be positively correlated with both anxiety and depression. All women with overactive bladder should be screened for anxiety and depression. There will be a paucity of research examining overactive bladder in Native American women and its correlation with anxiety and depression in this population.

Manuscript 2

Aim:

- What is the relationship between access to healthcare and risk factors that contribute to the development of pelvic floor dysfunction?
  - Do Native American women suffer from higher rates of these risk factors when compared to the general population of women?
- What is the relationship between obesity, diabetes mellitus, smoking, and parity, and rates of pelvic floor dysfunction?
- What is the relationship between pelvic floor dysfunction and mental health, specifically anxiety and depression?
- What is the relationship between mental health and quality of life?

Hypotheses

Decreased access to healthcare will be correlated with an increased incidence of risk factors that contribute to pelvic floor dysfunction in women. Native American

women will demonstrate higher rates of risk factors that contribute to pelvic floor dysfunction when compared to the general population of women. Women with pelvic floor dysfunction will have higher rates of anxiety and depression than women without the condition. Quality of life will be negatively impacted in women with anxiety and depression secondary to pelvic floor dysfunction.

Manuscript 3

***Aim*:**

- What is the predicted risk of Native American women developing overactive bladder?
- Are Native American women at a higher predicted risk of developing overactive bladder than women of other races?

Hypotheses

Native American women will have a higher predicted risk of developing overactive bladder when compared with the general population of women.

Chapter 2

The Association between Overactive Bladder and Mental Health in Natal Females and the Unknown in Native Americans: A State of the Science Review

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The Association between Overactive Bladder and Mental Health in Natal Females and the Unknown in Native Americans: A State of the Science Review

Overactive bladder (OAB) is a chronic disorder that impacts the health and lives of women around the world, with reported prevalence rates ranging from 18.7% to 48.3% depending on the population studied (Xue et al., 2020). In the United States, specifically, over 28 million women are affected by OAB disorder, which is characterized by urgent and frequent urination and, in many cases, urinary incontinence (UI) (International Continence Society, 2018; Xue et al, 2020). These symptoms are typically caused by an overactive detrusor muscle that can cause contractions in the bladder, leading to a feeling of needing to urinate even when one does not need to, and sometimes involuntary urination, also known as urinary incontinence, may occur as a result (American Urological Association, 2021; Chess-Williams & Sellers, 2023). This can occur when the pelvic floor is not functioning as it should or when bladder irritants (such as caffeine) are used (Lightener et al., 2019). Risk factors associated with the development of OAB include obesity, diabetes mellitus, smoking, and increased parity (Erekson et al., 2016; Kawahara et al., 2020; Møller et al., 2000). Symptoms of OAB are not merely an annoyance, but are associated with significant health consequences known to impact multiple domains of functioning and quality of life, causing significant and undue burdens on the women who experience OAB (Kinsey et al., 2014; Xue et al., 2020). These burdens include, but are not limited to, disruptions to social life, socioeconomic struggles, dermatological issues, and mental health consequences (Kinsey et al., 2014; Lai et al., 2016; Yates, 2020; Xue et al., 2020). Previous research has shown a significant decline in the quality of life related to OAB; however, this research also notes an

improvement in quality of life with the successful treatment of OAB symptoms (Aksak et al., 2022). With direct and indirect economic costs of OAB in the United States exceeding $60 billion annually (Coyne et al., 2014), some argue that this is as much a public health issue as it is a women's health issue (Durden et al., 2018; Xue et al., 2020).

A seemingly unrelated issue that has received more attention in the recent literature, is mental health symptomatology and its association with OAB and related physical health outcomes. Research has shown that chronic disease is often associated with mental health outcomes (i.e. asthma, COPD, and heart disease; Chapman et al., 2005; Daré et al., 2019) and OAB is not exception. Women specifically seem to experience a high rate of depression and anxiety related to physical health diseases, with these rates increasing when diagnoses are more chronic in nature (CITE). Furthermore, when examining women in childbearing ages, the mental health load is significantly increased as additional responsibilities and life stressors are apparent that can impact overall wellbeing and psychological fitness (Lin at al., 2020). Depression and anxiety are particularly prevalent issues in women, with roughly 10.5% of women diagnosed with depression (National Institute of Mental Health [NIH], 2022) and 13.3% of women diagnosed with an anxiety disorder (Lai et al., 2016). Those with chronic illness, however, are significantly more likely to experience mental health sequelae, with certain chronic illnesses leading to depression rates of nearly 90% in those diagnosed (Chapman et al., 2005). Similarly, rates of anxiety tend to be higher in people with one or more chronic illnesses, with a rate of approximately 33% (Daré et al., 2019). Furthermore, as few as 25% of women seek treatment for complications of OAB, due to stigma surrounding the disease, which can potentially exasperate or lead to mental health

concerns (Lukacz et al., 2017). It is important to evaluate for the presence of mental health symptoms in patients with chronic physical health issues such as OAB.

This State of the Science will focus on the relationship between OAB and mental health issues in women, but also pay attention to the experiences of underrepresented populations who may be at higher risk of experiencing OAB. Although we understand OAB and mental health in the general population of women, there is a dearth of research on these topics in Native American (NA) women, specifically. Even when diverse samples are included in studies, racial misclassification, or a lack of comprehensive racial and ethnic assessment, is a significant issue resulting in a dearth of vital health information that could provide rich content and direction for the health needs of Native American populations (Jim et al., 2019). Abigail Echo-Hawk, the director of the Urban Indian Health Institute, describes the issue of racial misclassification of Native Americans in research as "data genocide." One of the only studies evaluating the prevalence of UI in Native American women examined rates of one subcategory, stress urinary incontinence (SUI) (Fiegen et al., 2012) and only included a small discrete sample (N=234) from one specific tribal region. Although SUI is similar in symptomatology to OAB, etiologically, it is different (American Urological Association, 2020) which further limits the generalizability of this scant previous research in NA populations. This particular study concluded that more research was needed due to the unexpected findings which demonstrated lower rates of SUI in Native American women despite the presence of more risk factors; however, a follow up study has not been performed. With rich electronic health record data from the Indian Health Services and better capturing of racial and ethnic backgrounds in federally implemented epidemiologic

studies, further classification and understanding of disease states including OAB in NA populations is possible.

The purpose of this state of the science review is to provide a comprehensive overview of the extant literature addressing the association of OAB with mental health consequences, specifically anxiety and depression. The review will also include a subset examination of this question specifically in NA women. Where appropriate, findings will be reported, and discussion will be provided related to research supported policy recommendations to screen women with OAB for mental health concerns.

Method

Theoretical Concepts

This work is guided by the Biopsychosocial Model, which posits that biological, psychological, and social factors all play a role in one's overall health (Tong et al., 2021). If one of these areas is negatively affected, the other areas may be negatively affected as well. This is further demonstrated in a model previously described to address the negative cascading ramifications of poor access to healthcare in Native American women with a specific focus on pelvic floor dysfunction (Gramke et al., 2023 submitted for publication). This theory posits poor access to healthcare may lead to an increase in risk factors for pelvic floor dysfunction (which includes OAB) and, in turn, pelvic floor dysfunction, is associated with mental health sequelae including depression and anxiety. These mental health sequelae are known to decrease quality of life (Gramke et al., 2023 submitted for publication). Further, research theory and evidence has pointed to the Mind-Body issue in which physical health can directly impact emotional and mental health, resulting in complex symptomatology and diagnosis (Beban et al., 2021).

Optimistically, treatment of the physical disease can also result in the reduction of mental health consequences and improved quality of life (Aksak et al., 2022).

Data Sources and Retrieval Strategies

Databases used for this state of the science review include EBSCOhost, CINAHL, and PubMed. Key words used for this search include ("urinary incontinence" OR "pelvic floor dysfunction" OR "overactive bladder") AND ("anxiety" OR "depression"). Secondary criteria require at least a portion of the sample to be ("women" OR "female"). Inclusion criteria initially consisted of publications from 2016–2023, those that are peer-reviewed, and written or translated into English with the studies potentially conducted in anywhere in the world. Due to a paucity of available relevant literature, these criteria were expanded to include articles published between 2012 - 2023 to ensure a comprehensive examination of the current state of the science. Exclusion criteria included current pregnancy, participants under 18-years-old, and male-only populations. Relevant articles were kept and utilized, while duplicates were removed. If the direction of the correlation was reversed (articles in which anxiety caused the urinary issue rather than the other way around) and if the anxiety was short-term or situational (there were a number of articles discussing anxiety associated with urodynamic studies and not with the urological issue being examined on the urodynamic study), those articles were eliminated from this review. Initially, only literature examining U.S. populations was going to reviewed; however, due to a paucity of research on U.S.- only populations, the search was expanded to include worldwide research to facilitate a more comprehensive review of the topic.

Results

As detailed in the PRISMA diagram (see Appendix A), after utilizing the aforementioned search terms and filtering for the exclusion criteria, a total of 1,021 articles was produced. After removing duplicates (n=433) and articles not relevant to this state of the science review (n=570), 19 articles remained. Articles not relevant to the review included articles that in which there was no examination of the association between mental health and OAB, the direction of the correlation between OAB and mental health was reversed, those solely discussing stress urinary incontinence, articles in which the OAB symptoms were short-term or situational, articles focusing on male-only populations, and articles that discussed double incontinence (i.e., the leakage of both urine and stool). A total of 19 articles were examined for this review, which included primarily cross-sectional studies (n=17), one exploratory study, and one prospective study. Participants in all included studies were adults. The majority of the studies did not include interventions; however, Aksak et al. (2021) and Kinjo et al. (2019) examined the effect of medication (fesoterodine and mirabegron), examining whether anxiety improved with treatment of OAB symptoms.

While some studies did include men in the sample population (n=3), the majority studied women-only populations. The most common outcome measures related to mental health included self-report measures of anxiety and depression including the Hospital Anxiety and Depression Scale (HADS) (n=8), Patient Health Questionnaire (PHQ-9; n=3), and Perceived Stress Scale (PSS; n=3). Studies examination of OAB, including urge UI, also relied on self-report questionnaires including the International Consultation on Incontinence Questionnaire – Short Form (ICIQ; n=4), Incontinence Impact Questionnaire (IIQ; n=5), Urinary Distress Inventory (UDI-6; n=5), International

Consultation on Incontinence Questionnaire – Overactive Bladder (ICIQ-OAB; n=4), and Overactive Bladder Questionnaire (OAB-q; n=3).

Review of the Literature

The comprehensive review of the current literature regarding OAB and its association with mental health sequelae largely indicated a positive correlation between OAB and anxiety (n=4), depression (n=6), or both (n=7) (Table 2; Aksak et al., 2021; Alves et al., 2014; Felde et al., 2017; Firat et al., 2021; Kinjo et al., 2019; Hansson Vikström et al., 2019; Hung et al., 2014; Lai et al., 2016[a]; Lai et al., 2016[b]; Mehr et al., 2022; Melotti et al., 2018; Milsom et al., 2012; Patel et al., 2022; Reis et al., 2021; Teixeira et al., 2016; Vrijens et al., 2017; Yazdany et al., 2014). Further, there appears to be an association not only with OAB and the development of anxiety and/or depression, but between the severity of OAB symptoms and the severity of the subsequent mental health sequelae (Lai et al., 2016[a]; Mehr et al., 2021; Melotti et al., 2018).

Depression

Rates of depression reported in the literature appear to be much higher in women suffering from OAB with as many as 60% endorsing a depressive symptom (Lai et al., 2016[b]; Melotti et al, 2018; Milsom et al., 2012; Teixeira et al., 2016; Yazdany et al., 2014) as compared to the estimated depression rate of 10.5% in the general population of adult women (NIH, 2022). Rates of depression reported in the available literature ranged from 20.3 – 59.8%. Two of the articles also supported a correlation between the severity of OAB and the severity of depression, with women who experience more severe OAB symptoms endorsing more severe depressive symptoms ($p<0.001$-0.035; $r=0.24$-0.35, $p\leq0.05$) (Lai et al., 2016[b]; Mehr et al., 2022).

Symptoms of OAB are tolerated differently among those who experience them, with some finding the symptoms bothersome while others do not. This is described as "OAB with bother" and "OAB without bother" (Milsom et al., 2012). In the only study to examine the differences in OAB with bother and OAB without bother, Milsom et al. (2012) noted that depressive symptoms were much higher in women who were bothered by their OAB symptoms, with 37% scoring greater than or equal to 8 on the HADS-D scale, indicating the presence of at least mild depressive symptoms. In comparison, 19% of those who were not bothered by their OAB symptoms and only 10% of those who did not have OAB, or had minimal OAB symptoms, endorsed depressive symptoms (Milsom et al., 2012).

Mehr et al. (2022) was the only study to examine racial differences in the association between OAB and mental health sequelae; however, of the 69 participants, only three were non-White. Daily depressive symptoms, not just the presence of a depression diagnosis, were endorsed in eleven of the sixty-six White participants, one of the two Black participants, and zero of the sole "Other" participant. Due to the limited number of non-White participants in this study, inferences regarding the impact of race on OAB and its association with depression are severely limited.

One study evaluated the effectiveness of the treatment of UI on depressive symptoms. Aksak et al. (2021) examined whether severity of depressive symptoms decreased after treatment of UI with fesoterodine (Toviaz). Prior to treatment, the median HADS-D score was 8.93 ± 0.62 and the post-treatment median HADS-D decreased to 6.14 ± 0.72 ($p=0.013$), indicating that treatment of UI led to a reduction in depressive symptoms (Aksak et al., 2021).

Anxiety

When examining the extant literature pertaining to OAB and anxiety, 30.4 - 48% of women with OAB suffer from anxiety and, in approximately 24% of these women, the anxiety is described as moderate to severe (Alves et al., 2014; Lai et al., 2016[a]; Mehr et al., 2022). These reported anxiety rates are much higher than expected in the general population of women, with an estimated 13.3% experiencing symptoms of anxiety (Lai et al., 2016[a]). Research also supported a correlation between the severity of OAB and the severity of anxiety, with women who experience more severe OAB symptoms endorsing more severe anxiety symptoms (Spearman's correlation coefficients 0.29-0.47, $p<0.05$; $r=0.30\text{-}0.40$, $p\leq0.01$) (Lai et al., 2016[a]; Mehr et al., 2022). Degree of bother also appears to play a role in the development of anxiety with OAB (Milsom et al., 2012). Anxiety symptoms were much higher in women who were bothered by their OAB symptoms, with 49% (1,472 participants) scoring greater than or equal to 8 on the HADS-A scale, indicating the presence of at least mild anxiety symptoms. In comparison, 31% of those (455 participants), who were not bothered by their OAB symptoms and 17% of those (418 participants) who did not have OAB, or had minimal OAB symptoms, had a score greater than or equal to 8 on the HADS-A scale (Milsom et al., 2012).

Similar to depression, Mehr et al. (2022) also attempted to examine racial differences in daily anxiety symptoms in addition to an anxiety diagnosis. Daily anxiety was endorsed by eight of the sixty-six White participants, both of the Black participants, and zero of the sole "Other" participant. As previously discussed, based on the limited number of non-White participants included in this study, inferences regarding the impact of race on OAB and its association with anxiety would be of little value. Two additional

studies noted an improvement in anxiety symptoms with successful treatment of UI (Aksak et al., 2021; Kinjo et al., 2019). Aksak et al. (2021) suggest treatment of UI with fesoterodine (Toviaz) as they noted decreased levels of anxiety in patients who utilized this medication to reduce their UI symptoms (-0.279, p=0.022). Prior to treatment, the median HADS-A score was 10.17 ± 0.63 and the post -treatment median HADS-A decreased to 7.83 ± 0.68 (p=0.022) (Aksak et al., 2021). Kinjo et al. (2019) noted a decrease in anxiety after treating OAB with mirabegron (Mybetriq). The median baseline HADS-A score was 4 and, at week 4 of the study the median HADS-A score had decreased to 3 (p=0.041) and, at week 8, the median HADS-A score remained at 3 (p=0.044) (Kinjo et al., 2019).

No Association

Some literature, however, did not endorse a correlation between OAB, or UI, and mental health sequelae (n=4). While Siddiqui et al. (2018) did note an association between UI, depression, and anxiety, they did not find any evidence suggesting that UI was independently associated with these issues. Numerous limitations were noted in this study, including a lack of ethnic diversity and the fact that the participants were seeking care for their urinary symptoms at a specialty facility, which they acknowledge is not representative of the OAB population as a whole (Siddiqui et al., 2018). Further, there was no control group in this study with participants who did not have urological symptoms (Siddiqui et al., 2018). Similarly, no significant link between UI and depression was noted by Laganà et al. (2014); however, this study had numerous limitations, the strongest of which was a lack of actual medical tests to validate the participants' self-reported urological and mental health data. Another limitation of this

study was that participants were not asked if they were currently being treated for urological or mental health issues, which may have contributed to their urological and mental health symptomatology (Laganà et al., 2014). Although they did not note a correlation between OAB and anxiety, Djakovic et al. (2022) still recommend a psychiatric evaluation to assess for anxiety in all women with UI. The primary limitation of this study was its lack of differentiation between subtypes of UI, which they acknowledge may have varying degrees of impact on mental health symptomatology and quality of life, with UI related to urgency being more problematic for patients than stress urinary incontinence, for example (Djakovic et al, 2022). Hansson Vikstrom et al. (2022) did not note a significant increase in anxiety in women with UI. Their findings demonstrated 13.8% of women with UI, specifically urge urinary incontinence or mixed urinary incontinence (i.e., the presence of more than one type of incontinence) suffered from anxiety ($p=0.700$). These numbers are similar to the level of anxiety among the general population (Lai et al., 2016[a]). Hansson Vikstrom et al. (2022) do acknowledge some potential limitations with their study, specifically the fact that there may have been bias due to the fact that 80% of the women who participated had a college degree and had access to telehealth, indicating socioeconomic status could have played a role in these unexpected results.

Discussion and Synthesis

Discussion

Although the existing literature supports the association between OAB, and its related diagnoses, and depression and anxiety overall, with few exceptions, no literature examining the mental health outcomes of OAB were found pertaining to Native

American women. Only one study even included Native American women; however, they made up merely 1% of the study population. The mental health outcomes were not specified for each racial group, but all races as a whole. It is imperative that research on this topic in Native American women be conducted, as they face a unique set of circumstances that put them at higher risk of developing OAB including higher rates of obesity, diabetes mellitus type 2, smoking, and parity (American Psychological Association, 2015; CDC, 2021; Office of Minority Health, 2021; Sandefur et al., 1996). The literature currently available largely fails to examine the impact of race on the development of OAB or its mental health consequences. Two studies examined racial differences in OAB symptomatology; however, both of these studies were examining groups with existing urological issues (Milsom et al., 2012; Siddiqui et al., 2018). While Milsom et al. (2012) did not examine racial differences in the development of OAB, they did examine racial differences in the level of bother associated with OAB, with Black participants demonstrating the lowest level of bother (39.4%) and Asian participants demonstrating the highest level of bother (65.5%). Siddiqui et al. (2018) examined the number of patients with and without UI in a sample of women who were participants in the Lower Urinary Tract Research Network (LURN). Of the women in the sample, Native Hawaiian/Pacific Islander (NH/PI) women had a UI rate of 100% (however, there was only 1 NH/PI participant in the study), followed by African American women with a UI rate of 86.4% (Siddiqui et al., 2018). Laganà et al. (2014) notes that European-Americans had the highest rate of UI, with 31% of participants endorsing UI, while ethnic minorities, in general, had a UI rate of 26%. The racial/ethnic breakdown of these

results, and how these results were obtained, was vague and no table of findings was reported to break these findings down by race (Laganà et al., 2014).

Native American women face numerous barriers to health services and have poor access to healthcare compared to women of other races, with 26.4% of Native Americans lacking health insurance coverage (CDC, 2021) compared with 9.4% of the general population (Santori, 2021). In addition, Native Americans have the highest poverty rate (25.4%) in the US when compared with Black Americans (20.8%), Hispanic Americans (17.6%), and White Americans (8.1%) (Asante-Muhammad, 2022). A mere 3.3% of women endorse a provider-initiated discussion about UI, with low-income women being even less likely to have this discussion with their provider (Duralde et al., 2016). It is also worth noting that Native Americans also face barriers to mental health care and disproportionate rates of mental health issues (Santori, 2021), making it crucial to identify and treat disorders such as OAB that are suspected to increase the risk of certain mental health issues in an effort to mitigate this risk and improve both health equity and the overall quality of life in this population.

Limitations

Limitations of this study included a paucity of seminal works on the relationship between OAB and mental health issues in the US and internationally. Secondly, many of the articles being reviewed did not specify the race of the participants or break down findings based on race, making it difficult to assess whether race played a role in the findings. There was no consistent screening method utilized across the literature, with OAB and mental health being evaluated using numerous methods, including various screening tools and participants' self-report of symptoms and diagnosis. The literature

presented in the review included many different operationalizations and many different aspects of OAB, including different types of incontinence, making it difficult to determine whether OAB as a whole contributed to the findings, or if a subcategory of OAB was a larger contributor. Finally, the majority of the studies were cross sectional (N=17), placing them quite low on the hierarchy of evidence. This area of research would benefit from future studies that are meta-analyses or randomized control trials.

The dearth of research on NA women, specifically, was another limitation of this study. As previously discussed, only one study in this review explicitly included NA women and they made up only 1% of the study population (n=5). Further, there is a paucity of research on mental health issues in NA women that examine their mental health outside of pregnancy or substance use, making it difficult to establish specific baseline rates of depression and anxiety in this population.

Implications and Recommendations

That said, the overall dearth of research in this area indicates further research is needed, potentially on the epidemiologic level, to evaluate the overall prevalence of OAB in a rigorous way and identify the potential causal relationship between OAB and mental health outcomes. Based on the current literature available, researchers and clinicians should encourage providers to screen all women, regardless of race, aged 18 and older for OAB annually. Currently, no official guidelines exist regarding screening for OAB and its related diagnoses; as such further research could provide the data needed to develop and implement guidelines and policy to prevent and treat those with OAB. For those who screen positive for OAB, symptoms of depression and anxiety should be screened for as well with appropriate referrals to psychiatry recommended as indicated (Firat et al.,

2021). Further research is necessary to evaluate the impact of OAB treatments on mental health outcomes.

Future OAB research needs to ensure comprehensive inclusion and classification of race and ethnicity, prioritizing the inclusion of underrepresented minorities (e.g. Native American women) in the sample population. This will allow for a better understanding of OAB experiences in a diverse population and will inform the development of culturally appropriate treatment modalities and improved access to these treatments.

The relationship between OAB and mental health in Native American women is a significant gap in this area that must be addressed through further research. It is imperative to determine the impact that OAB has on Native American women's mental health so that recommendations for practice can be made to assist in mitigating these issues. Given that Native American women experience a higher prevalence of risk factors for OAB than the general population (Kawahara et al., 2020; Møller et al., 2000), as well as a higher incidence of mental health issues (Santori, 2021), the identification and treatment of OAB could be a crucial step in decreasing the mental health sequelae of this disorder and increasing the overall quality of life in this population. Through inclusion in research and development of culturally appropriate treatments, NA women's quality of life may be improved through the mitigation of OAB and its resultant mental health sequelae.

Conclusion

Overactive bladder has the potential to significantly and negatively impact the overall quality of life for women and is a public health issue costing the US $60 billion

dollars annually. Overactive bladder is a common problem, with nearly two-thirds of women experiencing symptoms of OAB at some point in their lives (Patel et al., 2022). As shown through the extensive review of the literature (Table 2), the research largely agrees that women who suffer from OAB are at a significantly elevated risk of developing anxiety and depression. By addressing the issue of mental health with each female patient complaining of OAB symptoms, providers have the potential to mitigate the exacerbation of mental illnesses that notoriously and significantly decrease quality of life (Steibliene et al., 2020). In order to understand and address the unique symptomatology and needs of all women, future research should not only include diverse populations of women, but analyze results based on race rather than merely using race as a demographic factor.

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Table 1. Critical Appraisal of the Existing Literature

Author/Year	Database	Sample	Level of Evidence	Instruments	Interventions	Findings/Conclusions
Association with Depression						
Hung, K. J., Awtrey, C. S., & Tsai, A. C. (2014)	EBSCOhost	N=4,511 women between 54-65 years White 85.7% Black 10.7% Other 3.6%	VI - CSS	The Health and Retirement Study Survey Center for Epidemiologic Studies – Depression Scale	None	UI related to increased probability of having depression (adjusted hazard ratio, 1.43; 95% CI 1.27–1.62) 16.6% had UI
Lai, H. H., Shen, B., Rawal, A., & Vetter, J. (2016)	EBSCOhost	N=81 51 OAB patients (43.1% White) (mean age 53.8) 30 age-matched controls (63.3% White) (mean age 54.2)	VI - CSS	HADS-D ICIQ-UI ICIQ-OAB OAB-q UDI-6 IIQ-7	None	OAB patients had higher depression scores on HADS-D compared to age-matched controls
Teixeira Alves, A., Jacomo, R.	EBSCOhost	N=169 older women	VI - CSS	Overactive Bladder (OAB-V8)	None	42.6% of those with OAB had mild to severe depression

H., Martins e. Silva, R. C., Barbaresco Gomide, L., dos Santos Bontempo, A. P., & Azevedo Garcia, P. (2016)		Brazilian study		Yesavage Geriatric Depression Scale		based on the scale used.
Yazdany, T., Bhatia, N., & Reina, A. (2014).	PubMed	N= 429 women Mean age 46.6 years Latino 56% Black 20% White 12% Asian 4% Other 8%	VI - CSS	PHQ-9 BDI-II SF-12 Health Survey	None	34.1% depression with UI (21% in those without UI)
Association with Anxiety						
Firat, F., Oztekin, U., Tokpinar, A., Caniklioglu, M., Gürtan, E., Tok, S., & Halis, F. (2021)	PubMed	N=125 women Mean age UI group 40.98 years Mean age control group 39.1 years Mean duration of incontinence in UI group 16.55 years	VI - CSS	BDI BAI SSAS HAI	None	Anxiety higher in UI group. Anxiety assessment should be included in UI diagnosis/treatment process.

		Race of participants not specified Turkish study				
Kinjo, M., Yamaguchi, T., Tambo, M., Okegawa, T., & Fukuhara, H. (2019)	PubMed	N=112 Japanese study	VI - CSS	OABSS HADS	Mirabegron	Improvement of OAB symptoms seemed to improve anxiety symptoms
Lai, H. H., Rawal, A., Shen, B., & Vetter, J. (2016)	EBSCOhost	N=81 men and women 51 OAB patients with average age 53.8, 43% White 30 age-matched controls with average age 54.2, 63.3% White No further specifications on race	VI – CSS	HADS-A HADS-D PSS CTES RTES ICIQ-UI (short form) ICIQ-OAB OAB-q Short Form UDI-6 IIQ-7	None	48% of OAB patients reported symptoms of anxiety (in 25% of OAB patients, anxiety was moderate to severe) OAB patients higher anxiety than controls OAB patients with anxiety had more severe OAB/UI and poorer quality of life
Alves, A. T., Jácomo, R. H., Gomide, L. B., Garcia,	PubMed	N=166 older women Brazilian study	VI - CSS	OAB-V8 BAI	None	70.5% with OAB

P. A., Bontempo, A. P., & Karnikoskwi, M. G. (2014)						Anxiety more prevalent in women with OAB
Association with Both Depression and Anxiety						
Aksak, A., Çakmak, G., & Öztürk, Z. A. (2021)	EBSCOhost	N=42 women Mean age 69.7 years Race of participants not specified Turkish study	IV - Prospective Study	ICIQ-SF I-QOL HADS-A HADS-D	Fesoterodine	Treatment of UI appears to have a positive effect on both depression and anxiety
Felde, G., Ebbesen, M. H., & Hunskaar, S. (2017)	PubMed	N=21,803 women Mean age 53 years Races of participants not specified Norwegian study	VI - CSS	Urinary incontinence questionnaire HADS-A HADS-D	None	UI is a predictor for anxiety and depression
Mehr, A. A., Kreder, K. J., Lutgendorf, S. K., Ten Eyck, P.,	PubMed	N=69 women with OAB Average age 63.3 years	IV – Observational Study	ICIQ Bladder diary Visual Analog Scale UDI (long form) IIQ-7 (short form) GAD-7	None	30.4% with anxiety diagnosis 47.8% with depression diagnosis

Greimann, E. S., & Bradley, C. S. (2022)		White 95.7% Black 2.9% Other 1.5%		PHQ-9 PSS		
Melotti, I., Juliato, C., Tanaka, M., & Riccetto, C. (2018)	PubMed	N=274 women Average age 50.2 years Races of participants not specified Brazilian study	VI - CSS	ICIQ-OAB BDI BAI	None	59.8% moderately of severely depressed 62.4% moderate to severe anxiety Correlation between intensity of OAB symptoms and depression and anxiety symptoms
Milsom, I., Kaplan, S. A., Coyne, K. S., Sexton, C. C., & Kopp, Z. S. (2012).	EBSCOhost	N=10,584 women N=9,416 men Average age roughly 56 (not specifically specified but alluded to) White, Black, Asian, Hispanic, Other included – percentages of sample not specified, though	VI - CSS	EpiLUTS survey OAB-q Short Form HRQL Scale HADS-A HADS-D	None	Those bothered by OAB were more likely to have poorer HRQL and suffer from depression and anxiety symptoms Women 49% of those with OAB with bother had HADS-A > 8, 31% of women with OAB without bother, compared to 17% with no/minimal OAB

		White is clearly predominant.				Women 37% of those with OAB with bother had HADS-D > 8, 19% ow women with OAB without bother, compared to 10% with no/minimal OAB
Reis, A. M., Brito, L. G. O., Lunardi, A. L. B., Pinto E Silva, M. P., & Juliato, C. R. T. (2021)	PubMed	N=234 women Average age 52.5 years Races of participants not specified Brazilian study	VI - CSS	ICIQ (short form) ICIQ-OAB DASS-21	None	High rates of anxiety and depression in women with UI
Vrijens, D., Berghmans, B., Nieman, F., van Os, J., van Koeveringe, G., & Leue, C. (2017).	PubMed	N=1,510 Mean age 57.1 years 89.2% female Race of participants not specified Dutch study	VI - CSS	HADS-A HADS-D	None	Anxiety and depression are prevalent (30.9% and 20.3% respectively) among those who suffer from pelvic floor disorders such as UI. 12% of depression and 7.4% of anxiety directly related to PFD .

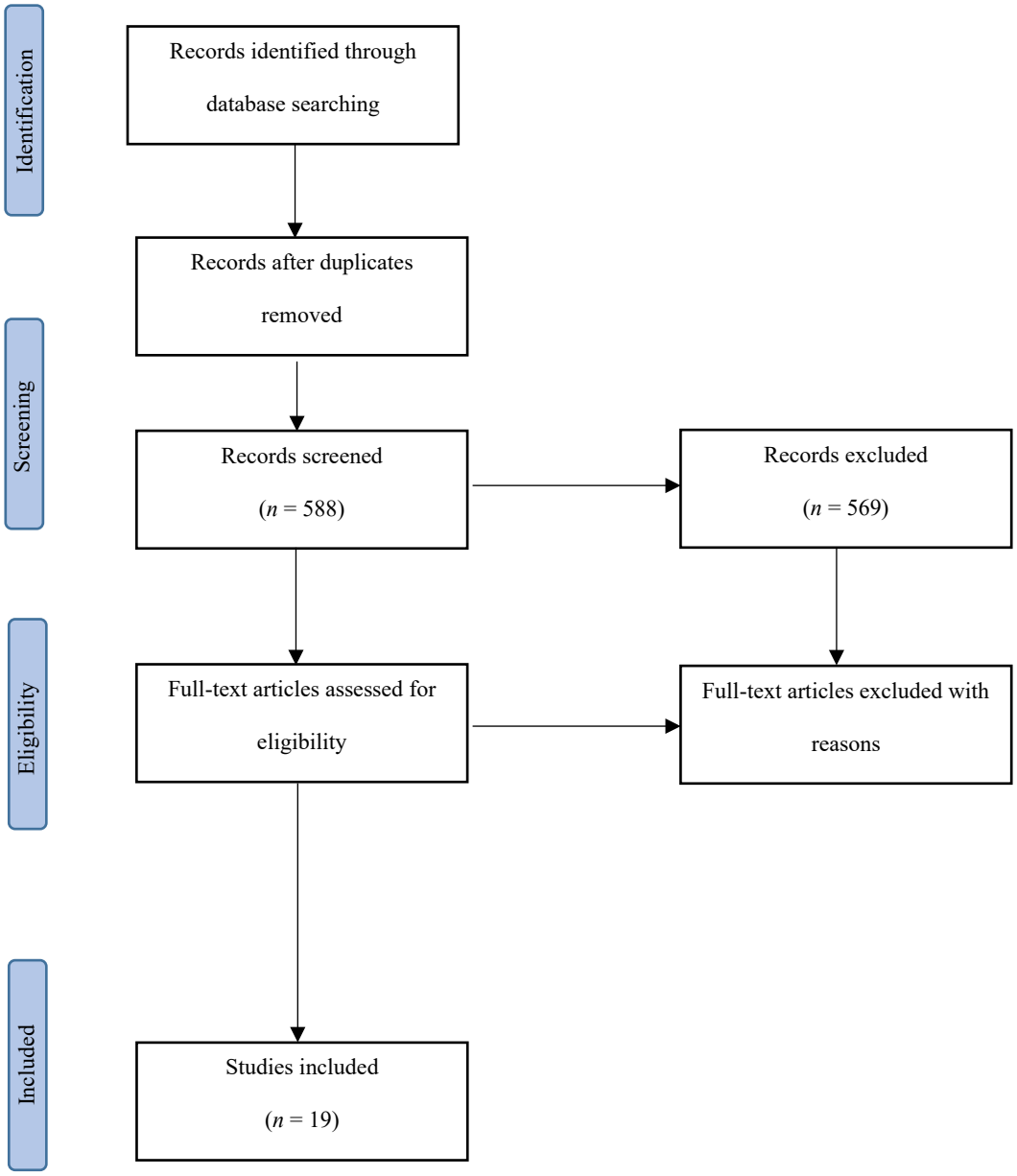
No Association						
Djaković, I., Soljačić Vraneš, H., Kraljević, Z., Nakić Radoš, S., & Vraneš, H. (2022)	PubMed	N=211 women Race of participants not specified Croatian study	VI - CSS	LSS SAS	Surgery for UI	Life satisfaction lower only in those who had undergone surgical option for UI. Possible limitations as these women may have had more severe UI symptoms prior to surgery and may have been let down by the improvements made through surgery. Life satisfaction similar in women with UI compared with post-menopausal women.
Hansson Vikström, N., Wasteson, E., Lindam, A., & Samuelsson, E. (2021)	PubMed	N=373 women Races of participants not specified Swedish study	VI - CSS	ICIQ-UI-SF HADS-A HADS-D	None	Women with SUI less likely to have depression than UUI or MUI - odds ratio of having depression was 4.2 (95% CI = 1.4–12.3) No significant difference in anxiety

						Prevalence of anxiety and depression lower than in other cross-sectional surveys Findings possibly related to socioeconomic differences
Laganà, L., Bloom, D. W., & Ainsworth, A. (2014).	PubMed	N=140 community dwelling older women Mean age 69 European American 44.3% Mexican American 17.6% Asian American 16% Other Hispanic/Latino 11.5% Black 10.7%	VI - CSS	UDI IIQ	None	UI-Depression link not significant
Siddiqui, N. Y., Wiseman, J. B., Cella, D., Bradley, C. S., Lai, H. H., Helmuth,	PubMed	N=510 women Average age 56 years White 82%	VI – observational CSS	Lower urinary tract symptom Tool PROMIS PSS IPAQ-SF	None	Higher severity of UI associated with higher anxiety and depression; however, UI not independently associated with

M. E., Smith, A. R., Griffith, J. W., Amundsen, C. L., Kenton, K. S., Clemens, J. Q., Kreder, K. J., Merion, R. M., Kirkali, Z., Kusek, J. W., Cameron, & A. P. (2018).		African-American 12% Hispanic/Latino 3% Asian 3% Multi-Racial/Other 2% **AI/AN 1% (5 participants/510)** NH/PI 0% (1 participant)				differences in mental health

Note: Beck Anxiety Inventory (BAI), Beck Depression Inventory (BDI), Childhood Traumatic Events Scale (CTES), Depression Anxiety and Stress Scale (DASS-21), Generalized Anxiety Disorder-7 (GAD-7), Hospital Anxiety and Depression Scale – Anxiety (HADS-A), Hospital Anxiety and Depression Scale – Depression (HADS-D), Health Anxiety Inventory (HAI), Health Related Quality of Life Scale (HRQL Scale), International Consultation on Incontinence Questionnaire – Overactive Bladder (ICIQ-OAB), International Consultation on Incontinence Questionnaire – Short Form (ICIQ-SF), International Consultation on Incontinence Questionnaire – Urinary Incontinence (ICIQ-UI), Incontinence Impact Questionnaire (IIQ-7), Incontinence Quality of Life (IQOL), International Physical Activity Questionnaire – Short Form (IPAQ-SF), Lifestyle Satisfaction Scale (LSS), Overactive Bladder – questionnaire (OAB-q), Overactive Bladder Symptoms Score (OABSS), Overactive Bladder Awareness Tool (OAB-V8), Patient Health Questionnaire (PHQ-9), Patient-Reported Outcomes Measurement Information System (PROMIS), Perceived Stress Scale (PSS), Recent Traumatic Events Scale (RTES), Zung Self-Rated Anxiety Scale (SAS), (SF-12 Health Survey), Somatosensory Amplification Scale (SSAS), Urinary Distress Inventory (UDI-6)

Figure 1. PRISMA Flow Chart



Chapter 3

Theoretical Considerations of Poor Access to Healthcare and Pelvic Floor Dysfunction in Native American Women

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Introduction

In the United States, more than 28 million women have been diagnosed with pelvic floor dysfunction, and it is estimated by 2050 that 43.8 million women will be diagnosed with this disorder (Wu et al., 2009). The incidence and prevalence of pelvic floor dysfunction are not known for Native American women because epidemiologic statistics have been reported for the overall population by race but have not included a subgroup analysis of Native Americans. Therefore, this article reports data largely on the general population, highlighting literature on Native American women whenever possible. The model presented is a conceptual representation about pelvic floor dysfunction created by two authors with Native American backgrounds and others also interested in focusing on studying Native American healthcare issues.

Pelvic floor dysfunction is a common problem affecting as many as 50% of women in the general population (Lee et al., 2021b). In this disorder, there is too much or not enough tension in the pelvic floor muscles. This problem can happen with or without experiencing childbirth. Consequences of pelvic floor dysfunction, for example urinary incontinence, can interfere with normal activities of daily living. Despite the life-altering consequences associated with pelvic floor dysfunction, as few as 25% of women with symptoms seek treatment, in part because of the stigma associated with the symptoms of this disorder (Hannestad et al., 2002). When they do seek treatment, only 3.3% of women report their provider initiating any discussion about consequences of pelvic floor dysfunction, such as urinary incontinence (Duralde et al., 2016).

Women with pelvic floor dysfunction are more likely to feel socially isolated (Yip et al., 2013) and experience symptoms of depression and anxiety (Lai et al., 2016). While

pelvic floor dysfunction and associated outcomes have been established in the general population, there is a paucity of research examining the impact of pelvic floor dysfunction in Native American women and help-seeking for this disorder. Without treatment, the disorder does not resolve and may worsen. The lack of access to healthcare means that Native American women may lack understanding about the disorder and that treatment options are available (Cromer et al., 2019).

The federal government has established core needs that must be met to ensure that minimum access to healthcare is achieved including coverage, services, timeliness, and workforce (Agency for Healthcare Research and Quality [AHRQ], 2018). In order for access to healthcare to be considered adequate, patients must (a) have sufficient insurance coverage to ensure they are not left with heavy financial burdens as the result of receiving routine care, (b) have preventive and treatment services available in their locale, and (c) be able to receive needed care in a timely manner without significant delays. In addition, a capable workforce that is large enough to meet patients' needs is essential (AHRQ, 2018). If a patient does not have all of these core needs met, they do not have adequate access to healthcare (Office of Disease Prevention and Health Promotion [ODPHP], 2010). The patient must also have access to culturally competent providers who can meet needs specific to the population (ODPHP, 2010).

In addition to the stigma surrounding pelvic floor dysfunction symptoms for the general population of women, in the case of Native Americans, social determinants of health are also active barriers to obtaining healthcare. Underfunding of the Indian Health Service, lack of healthcare providers in the rural and remote areas where many Native American women live, transportation issues, inability to afford health coverage (Ely,

2018), and inadequate cultural care are barriers that Native Americans often face (Zabat, 2020). These barriers deter many Native Americans from receiving routine annual medical appointments (Ely, 2018); specialized medical care for issues such as pelvic floor dysfunction is even less likely.

The purpose of this article is to connect theoretical considerations to research by presenting a model that depicts the negative cascading ramifications of poor access to healthcare in Native American women, focusing on the life-altering problem of pelvic floor dysfunction. There is currently a paucity of research evaluating its physical consequences and mental health sequelae in Native American women.

Theoretical Considerations

Approximately 30% of Native Americans rely solely on the Indian Health Service for their healthcare needs; however, as of 2016, the Indian Health Service is only capable of meeting half the needs of the Native Americans it serves due to insufficient governmental funding (Centers for Medicare and Medicaid Services, 2016). As a result, many Native Americans must attempt to obtain supplemental insurance to fill in the gaps. Approximately 36% of Native Americans obtain private insurance, while 34% obtain Medicaid, leaving 30% without coverage and completely reliant on the Indian Health Service (George Mason University, 2022).

Poor access to healthcare in the Native American community is related to increased risk of overweight, diabetes mellitus, smoking, and increased parity (Figure 1). These risk factors are all present in Native American women at higher rates than the general population (Kawahara et al., 2020; Møller et al., 2000). Over half of Native American women are overweight (American Psychological Association, 2015), whereas

27.5% of women in the general population are considered overweight (U.S. Department of Health and Human Services, 2021). The Office of Minority Health (2021) reported that over 14% of Native American women are diagnosed with diabetes mellitus, which is significantly higher than the rate of 6.6% for non-Hispanic White women. The Native American population has the highest prevalence of smoking of any racial group in the U.S. (Centers for Disease Control and Prevention, 2019). They also have increased parity compared to women in other racial groups (Sandefur et al., 1996).

Factors associated with an increase in the risk of pelvic floor dysfunction and its consequences are presented in Figure 1. The physical consequences are urge urinary incontinence, stress urinary incontinence, overactive bladder, pelvic pain, and nocturia. Fifty-four percent of women over the age of 20 suffer from these consequences (Suskind, 2020). The risk of urinary incontinence is significantly higher in women who are overweight (Erekson et al., 2016). There is a significant positive correlation between diabetes and urinary incontinence, due in part to certain aspects of diabetes such as hyperglycemia, which increases the volume of urine and negatively impacts the function of the bladder muscle (Hanna-Mitchell et al., 2013). Diabetes has also been shown to increase the risk of nocturia (Yoshimura et al., 2004). Due to its irritating effect on the bladder, smoking can increase overactive bladder as well as incontinence (Kawahara et al., 2020). Novo et al. (2020) reported a positive correlation between the number of vaginal deliveries and urinary incontinence. Pregnancy, as well as delivery, can actually damage pelvic floor muscles due to stress, stretching, and strain on the muscles leading to issues with pelvic floor dysfunction, including pelvic pain (Queensland Health, 2023).

Further complicating the epidemiology and treatment, pelvic floor dysfunction and its consequences are correlated with mental health sequelae (Figure 1). For example, approximately 15% of women suffer from pelvic pain and, of those, 95.2% suffer from at least one mental health diagnosis (Miller-Matero et al., 2016) including depression and anxiety. Forty-seven percent of women with physical consequences of pelvic floor dysfunction experience mild to moderate depression (Lai et al., 2016; Lee et al., 2021a; Mazi et al., 2019). In addition, the literature largely supports an association between pelvic floor dysfunction and anxiety (Mehr et al., 2021; Melotti et al., 2018; Siddiqui et al., 2018). Forty-eight percent of women with physical consequences of pelvic floor dysfunction experience symptoms of anxiety (Lai et al., 2016). This is significantly higher than in the general female population, in which only 13.3% of women experience anxiety (Lai et al., 2016). While these findings point to a clear relationship between pelvic floor dysfunction and mental health sequelae in the general female population, this research has not been conducted in Native American women, despite higher rates of mental illness and suicide in this population coupled with barriers to accessing care for mental health (National Alliance on Mental Illness, 2023). Both depression and anxiety can be overwhelming and have been shown to have life-altering effects including a decrease in overall quality of life (Cramer et al., 2005; Juárez-Rojop et al., 2018; Figure 1). For example, overactive bladder is associated with low quality of life (Kreydin et al., 2021).

In summary, poor access to healthcare is associated with increased risk of overweight, diabetes mellitus, smoking, and increased parity. These factors, in turn, increase the risk of pelvic floor dysfunction and its consequences, which are urge urinary

incontinence, stress urinary incontinence, overactive bladder, pelvic pain, and nocturia. Pelvic floor dysfunction and its consequences are associated with the mental health sequelae, depression and anxiety. These mental health sequelae are known to decrease quality of life. As Native American women experience higher rates of obesity, diabetes mellitus, smoking, and parity – all risk factors for pelvic floor dysfunction – it is important to examine the incidence of pelvic floor dysfunction in this population and understand barriers to treatment in order to implement upstream, culturally appropriate interventions that can reduce the disease burden in this population.

Implications

Native American women with pelvic floor dysfunction could benefit from access to treatment; however, access to specialist services, like pelvic floor physical therapy, is often out of reach for Native American women due to a lack of these services within Indian Health Service facilities and near reservations (Nahian & Jouk, 2022). Physical therapy is a first-line treatment and is more cost-effective than surgery or medication and is highly effective in the treatment of pelvic floor dysfunction, with as many as 80% of participants noting improvement (Chiang et al., 2021; Vaz et al., 2019; Wallace et al., 2019). Regarding Native Americans, no published statistics were found pertaining to rates of treatment seeking, reception, adherence, or outcomes. Further research should be conducted to investigate which treatment modalities for pelvic floor dysfunction would be preferred by Native American women.

For those Native American women who have access to care, practitioners must take cultural preferences into account when offering treatment for pelvic floor dysfunction, as many Native American women may prefer a more traditional or alternative approach to healthcare (Johnston, 2002). Further research should be conducted to investigate what traditional medicine practitioners and Native American women are currently doing to treat symptoms of pelvic floor dysfunction.

Poor access to care results in no, or almost no, mental healthcare related to pelvic floor dysfunction. Adding to this problem, according to recent news reports, mental health deserts (The Daily Yonder, 2023) and women's health deserts are on the rise (Kindelan, 2022), making access to services for pelvic floor dysfunction and its mental health consequences far more difficult and, in some cases, impossible. Practitioners should be aware of the mental health sequelae of pelvic floor dysfunction and perform mental health screenings on every Native American woman who presents with any of the physical consequences of pelvic floor dysfunction. With diminished access to care, many Native American women will be forced to deal with the life-altering problem, pelvic floor dysfunction, without medical aid that could further lead to declines in mental health and quality of life. Yet, budgetary reforms for the Indian Health Service could improve access and outcomes.

The Indian Health Service currently covers 2.56 million Native Americans. It is likely that budgetary reforms to increase healthcare access could benefit over one million Native American women. Recent news reports reveal that the current administration's most recent budget proposal emphasizes the importance of including tribal members in budget discussions, increasing funding to the Indian Health Service, and ensuring that

this funding is mandatory rather than discretionary (Trahant, 2022). This could be a starting point for addressing the issue of poor access to care and increase Native American women's access to specialist services such as pelvic floor physical therapy and mental health services, leading to improved outcomes.

Historically in the United States, the language of hundreds of treaties included the "promise of all proper care and protection." This resulted in a federal trust responsibility to provide services (often explicitly including housing, education, and health care) to tribal nations. To uphold such trust responsibilities, an increase to the Indian Health Services budget is vital. The inclusion of mental health services would likely greatly assist in the culturally appropriate provision of specialized services to address significant medical issues such as pelvic floor dysfunction. To best advocate for access to healthcare for everyone, those considering policy and legislative change must be assisted to recognize the importance of issues like this which may be hidden from view, yet disproportionately impact our native nations, greatly impacting the quality of life for those entrusted to our care.

Conclusion

Based on the proposed model, it is clear that future research in Native American women is needed on incidence, prevalence, rate of treatment, treatment effectiveness, reception, adherence, and outcomes. Native American access to healthcare must be improved in an effort to decrease the prevalence of risk factors that can contribute to the development of pelvic floor dysfunction and its life-altering consequences, including mental health sequelae that can decrease overall quality of life. Further research specifically examining ways to increase access to specialty services such as pelvic floor

physical therapy is crucial to addressing this problem. Through increased access to healthcare, pelvic floor dysfunction and its consequences can be mitigated, leading to an improved quality of life for Native American women suffering from this condition.

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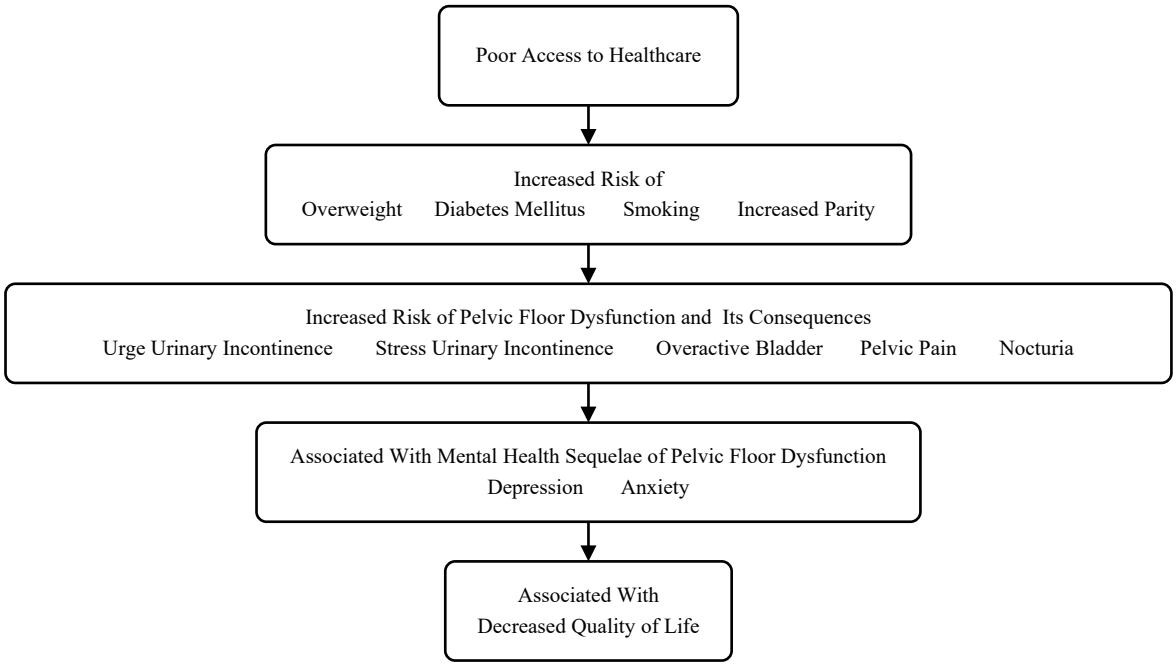
Figure 1

The Negative Cascading Ramifications of Poor Access to Healthcare in Native American Women, Focusing on the Life-Altering Problem of Pelvic Floor Dysfunction



Chapter 4

Estimated Risk for Urinary Incontinence and Related Mental Health Consequences in Native American Women

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Estimated Risk for Urinary Incontinence and Related Mental Health Consequences in Native American Women

Overactive bladder (OAB) is a prevalent problem, characterized by the feeling of urinary urgency, urinary frequency and, in many cases, urinary incontinence, defined as the involuntary loss of urine (American Urological Association, 2021). It is estimated that direct and indirect costs associated with OAB exceed $60 billion annually and the disorder currently affects nearly 30 million women in the United States, alone (Coyne et al., 2014; International Continence Society, 2018; Xue et al, 2020). Along with the physical consequences resulting from OAB, such as incontinence-associated dermatitis, this disorder is also known to lead to social isolation due to embarrassment, socioeconomic issues due, in part, to lost work time associated with OAB, and increase one's risk of mental health sequelae like depression and anxiety (Kinsey et al., 2014; Lai et al., 2016; Yates, 2020; Xue et al., 2020).

Although the prevalence, burdens, and expense associated with this disorder are high, there is a paucity of research evaluating the prevalence of OAB in Native American women, despite higher rates of risk factors commonly associated with OAB, including obesity, diabetes mellitus, smoking, and increased parity (American Psychological Association, 2015; Centers for Disease Control and Prevention [CDC], 2022a; Kawahara et al., 2020; Møller et al., 2000; Office of Minority Health, 2021). Current research suggests that roughly half of Native American women are overweight, compared to just over a quarter of the general population of women (American Psychological Association, 2015; U.S. Department of Health and Human Services, 2021). The rate of diabetes mellitus in Native American women is estimated to be 14%, more than two times the rate

in the White population of women (Office of Minority Health, 2021). Furthermore, 16.5% of Native Americans smoke, the highest smoking rate of any other race in the US. Subsequently, smoking can increase the risk of diabetes mellitus which, as previously discussed, is another risk factor for OAB (CDC, 2022a; CDC, 2023). Considering that the risk of OAB is theoretically higher in the Native American population due to the higher prevalence of known risk factors, it is imperative to examine this topic further in this population to mitigate the risk of the potential mental health sequelae of OAB since the Native American population already faces higher rates of mental health struggles and suicide than the general population (National Alliance on Mental Illness [NAMI], 2023; National Congress of American Indians [NCAI], 2020). Furthermore, the treatment of OAB and its consequences may be difficult or completely out of reach for many Native American women due to low rates of insurance coverage, with an estimated 26.4% lacking health coverage (CDC, 2023).

The purpose of this study is to utilize unsupervised machine learning to develop a predictive model which examines the clustering of risk factors identified for White and Native American women developing overactive bladder. While there are some data examining the association between over active bladder and its mental health consequences in general, there is a dearth of information on this topic in Native American women. Determining the potential risk and factors that may drive risk in these populations could lead to screening recommendations to reduce or mitigate the risk of urinary incontinence and its mental health consequences in Native American women. This study aims to determine use this novel unsupervised machine learning approach to test the fit of risk factors identified in the literature in predominately White female

samples and if the model also fits Native American women using data from the BRFSS. The overall goal is to gain a better understanding of important risk factors for Native American women developing overactive bladder to inform future practice and research.

Methods

Data Collection

Secondary data and relevant codebooks from the Center for Disease Control (CDC) Behavioral Risk Factor Surveillance System (BRFSS) were utilized through open access CDC website and prepared for analysis. An Institutional Review Board (IRB) human subjects research determination form was completed prior to data analysis and received acknowledgement by the IRB that this research was not considered human subjects research. The dataset utilized was the BRFSS Annual 2020 Survey. The total dataset includes 397,032 participants, of which 6,954 are Native American/American Indian. For the purposes of this study, the BRFSS dataset was filtered to display only White and Native American women who were not currently pregnant at the time of the survey. Respondents whose current "pregnancy status" was "yes," "don't know/not sure," or "refused" were not utilized in the analysis since pregnancy can lead to short-term urinary incontinence (Sangsawang & Sangsawang, 2013). After filtering the BRFSS dataset in SPSS to include only non-pregnant White and Native American women, age-matched controls were created in R by a clustering unsupervised machine learning method via k-means resulting in a total sample 10,083 women included in the modeling.

Variables Examined and Creation of New Variables

Predictor variables known to increase the risk of overactive bladder in White women were identified through a comprehensive review of the literature (Gramke et al., unpublished) and discovered in the dataset. These predictor variables, detailed below, included tobacco use and issues related to physical health including diabetes and obesity, and demographic information including parity and health coverage. In order to compute continuous variables and multi-level ordinal and categorical variables necessary for appropriate unsupervised machine learning, indicators from the BRFSS were combined where appropriate. Descriptive statistics for the total sample and stratified by race are reported in Table 1.

Demographics

Sex of Respondent (_SEX) was utilized to determine the natal sex of the respondent. Responses include male and female. Only those who reported they were both born female at birth and currently identify as a woman were included in the final sample used from analyses.

Age (AGE80) was collected to determine respondents' age. Age was used to match the samples of White and Native American women and included in the ML algorithm as a potential risk factor for OAB.

Race/ethnicity Multiple variables were collected to assess the respondent's racial and ethnic background including racial categories as well as Hispanic ethnicity origin. (_RACE) was computed to characterize the respondent's racial/ethnic background considering race and Hispanic origin concurrently. Only those who identified as White or Native American were included in the study.

Annual Household Income (_INCOMG) provides information on annual household include within a categorical framework (<$15,000, $15K-<25K, $25K-<35K, $35K-<50K, >$50k).

Number of Children in Household (CHILDREN) was asked to determine the number of children under the age of 18 living in the respondent's household. Responses included values ranging from 1 – 87 indicating the number of children in the respective household. Other responses include none and refused.

Tobacco Use

Current Smoking Status (_SMOKER3) was assessed to determine if the respondent is an everyday smoker, someday smoker, former smoker, or non-smoker.

Length of Time Since Last Smoked (LASTSMK2) was assessed to determine the length of time since the respondent had last smoked even one puff of a cigarette. Possible responses were within the past month (less than 1 month ago), within the past 3 months (1 month but less than 3 months ago), within the past 6 months (3 months but less than 6 months ago), within the past year (6 months but less than 1 year ago), within the past 5 years (1 year but less than 5 years ago), within the past 10 years (5 years but less than 10 years ago), 10 years or more, never smoked regularly, don't know/not sure, and refused.

A continuous smoking variable was created by combining current smoking status (_SMOKER3) and length of time since last smoked (LASTSMK2) to best capture and demonstrate the length of time respondents had smoked. Values for

this new variable ranged from 0, indicating the participant is a non-smoker, to 9, indicating the participant is an every day smoker.

Mental Health

Number of Days Mental Health Not Good (MENTHLTH) was asked to respondents to determine if they have experienced any issues with stress, depression, or their overall emotions in the past 30 days. Responses include values ranging from 1 – 30 indicating the number of days the respondent experienced any problems with their mental health. Other responses include none, don't know/not sure, and refused.

Ever Told You Had a Depressive Disorder (ADDEPEV3) was queried to determine if respondents have ever received an actual diagnosis of any depressive disorder, including depression, minor depression, major depressive disorder, or dysthymia. Responses include yes, no, don't know/not sure, and refused.

Physical Health and Related Factors

Diabetes.

Ever Told You Had Diabetes (DIABETE4) was asked to determine if respondents have ever been diagnosed with diabetes. Responses specified if this diagnosis was pre-diabetes or gestational diabetes. Responses include yes, yes but female only told during pregnancy, no, no – pre diabetes or borderline diabetes, don't know/not sure, and refused.

Age When Told Diabetes (DIABAGE3) was asked to determine the age at which the respondent was diagnosed with diabetes with responses ranging in value

from 1 – 97 to indicate the age at diagnosis, with 97 indicating 97 or older. Other responses include don't know and refused.

To determine the amount of time each participant had lived with diabetes a new variable was created. This was done by subtracting the age the participant was when they were diagnosed with diabetes from their current age.

BMI

Reported Weight in Pounds (WEIGHT2) asked respondents their current weight in pounds without shoes. If the responded chose to answer in pounds, they were instructed to respond with a value ranging from 50 – 0776 while they were instructed to respond with a value ranging from 9023 – 9352 if they planned to list their weight in kilograms, with the initial 9 indicating a metric value. Other responses include don't know/ not sure and refused.

Reported Height in Feet and Inches (HEIGHT3) was asked to determine the height of respondents. For those responding in feet and inches, they were instructed to input a value of 200 – 711 following a formula of "0 _ / _ _ = feet / inches." For those responding in meters and centimeters, they were instructed to input a value of 9061 – 9998, with the initial 9 indicating a metric value. Other responses include don't know/not sure and refused.

The aforementioned variables were corrected to ensure all data was reported in imperial measurement (pounds and inches). These data were used to compute a variable for BMI by inputting the BMI formula (weight in pounds / (height in inches * height in inches) * 703) into an SPSS syntax (CDC, 2022b). BMI was included in the machine learning algorithm.

Pregnancy

Pregnancy Status (PREGNANT) was asked to determine if the respondent was currently pregnant at the time the survey was conducted. Responses include yes, no, don't know/not sure, and refused. This question was only asked to respondents who are natal females and under the age of 49. As pregnancy specific acute OAB can occur, anyone who reported they were pregnant were excluded from the final sample.

Access to Healthcare

Have Any Health Care Coverage (HLTHPLN1) was queried to determine if the respondent has health coverage at the time of the survey. Health coverage was specified to include health insurance, HMOs, or governmental plans which include Medicare or Indian Health Service. Responses include yes, no, don't know/not sure, and refused.

Health Care Coverage and Cost (HLTHPLNCOST) was calculated by combining two variables, HLTHPLN1 and MEDCOST, to determine if the respondent had insurance coverage at the time of the survey and if they struggled with costs associated with healthcare.

Most recent visit to primary care (CHECKUP1) was used to determine the amount of time since the respondent had been for a routine medical check. Responses included within past year (anytime less than 12 months), within past 2 years (1 year but less than 2 years ago), within past 5 years (2 years but less than 5 years ago), 5 or more years ago, don't know/not sure, never, and refused.

Unsupervised Machine Learning

Data was managed and analyzed in SPSS and R utilizing unsupervised machine learning to develop a risk prediction model evaluating the risk of Native American women developing urinary incontinence.

In data science, supervised learning is a machine learning algorithm that uses a dataset consisting of independent and dependent (outcome) variables. Alternatively, a machine learning algorithm that uses a dataset that only includes independent variables, with no outcome variable available, is called unsupervised learning. In supervised learning, the algorithm is trained on the dependent variable and is then used to generate predictions on independent variables (Kotsiantis, 2007). In unsupervised learning, a model is trained on independent variables and automatically learns from those variables by extracting features and patterns from it. K- means clustering is one of the unsupervised machine learning methods that can be applied to datasets that do not have a dependent variable. This approach relies on the previous literature to identify important risk factors to input as the independent variables into the algorithm. The ultimate goal is to identify clusters of data that will identify differential risk groups for a particular unknown outcome.

In machine learning, training and testing data are used to train and evaluate a model's performance. Training data is the labeled data used to train a machine-learning model. The model learns patterns and relationships within the training data to make predictions or classifications. The aim of this process is to find the best possible parameters or weights for the model to minimize errors and optimize performance. Testing data is a separate set of data used to evaluate the performance of a trained machine-learning model. It is used to assess how well the model generalizes to unseen

data. The training and testing datasets are typically split from a larger dataset. Common practices include using a random split (e.g., 75% for training and 25% for testing).

K-means clustering

Clustering is a technique for finding subgroups or clusters in a dataset. This technique clusters the participants in a dataset into distinct groups so that each group consists of participants with similar characteristics (James et al., 2021). K-means is a clustering method that groups data into K clusters. K presents the number of clusters in the analysis. K-means clustering assigns each participant to one of the K clusters based on the similarity of the participants with other participants in the cluster. The algorithm decides the number of clusters, K, based on a minimum variation within each cluster.

In clustering analysis, the concept of between_SS (between-cluster sum of squares) and total_SS (total sum of squares) are used to evaluate the quality of clustering results. Total_SS (Total Sum of Squares): Total_SS represents the sum of squared distances between each data point and the centroid of the entire dataset. It measures the total variability or dispersion of the data. It can be calculated as the sum of squared distances between each data point and the overall centroid of the dataset.

Between_SS (Between-Cluster Sum of Squares): Between_SS represents the sum of squared distances between the centroids of each cluster and the centroid of the entire dataset. It quantifies the separation or difference between the cluster centroids. It can be calculated as the sum of squared distances between each cluster centroid and the overall centroid of the dataset, multiplied by the number of data points in each cluster.

The ratio between_SS/total_SS is a measure of how well the clusters are separated compared to the total variability of the data. It indicates the proportion of the total sum of

squares that can be attributed to the separation between clusters. A high ratio between_SS/total_SS indicates that a large portion of the total variability is accounted for by the separation between clusters, suggesting good cluster separation. On the other hand, a low ratio implies that the clusters are not well-separated or that the within-cluster variability is high relative to the between-cluster variability.

To complete the clustering analysis, R software and programming language with *factoextra* package were used (Kassambara & Mundt, 2020). In this study, we considered 75% of the White sample as a training dataset to monitor which variable to use for clustering and 25% Native American sample as a test dataset. Due to the fact that the vast majority of literature examining prevalence and risk factors for OAB is in White women, the training dataset included only White women. In order to determine the fit of the model for Native American women, only Native American women were included in the test dataset. This was done to determine how much the monitored variables from White women worked with Native American women by comparison of the ratio between_SS/total_SS from both clustering sets. The two models are reported below. The sample size for the White population (n=7620) was larger than the sample size for the Native American population (n=2463) as the training dataset is intended to be larger than the test dataset in machine learning and because there is a higher proportion of White women than Native American women in the general population.

Results

Demographic Characteristics of White and Native American Samples

Demographic characteristics are reported in Table 1. In order to protect against type-2 error related to multiple comparisons a more conservative significance value of

$p<0.01$ was used for statistical testing. The average BMI was 28.07 (SD 6.92) in the White sample. Of the White sample, 6.1% (n=469) had an income less than $15,000, while 41% (n=3122) had an income greater than $75,000. General health statistic reported 61.5% (n=4690) of White women stating that their health was “excellent” or “very good” and 12.2% (n=927) who endorsed health that was “fair” or “poor”. A vast majority of White respondents (94.4%; n=7197) endorsed having healthcare coverage. Health costs were a struggle for 9% (n=691) of the White sample. White women, on average, had been living with diabetes for 1.21 years. In the White population, 14.7% (n=1117) of the population endorsed smoking at least some days, with 61.7% (n=4698) of this sample identifying as non-smokers.

In the Native American sample, the average BMI was 29.75 (SD 7.23). Of the Native American sample, 21% (n=517) had an income less than $15,000, while 15.4% (n=379) had an income greater than $75,000. The general health statistic reported 40.3% (n=993) of Native American women stating that their health was “excellent” or “very good” and 24.9% (n=615) who endorsed health that was “fair” or “poor”. A vast majority of Native American respondents (92.1%; n=2269) endorsed having healthcare coverage. Health costs were a barrier for 13.5% (n=334) of the training sample. Native American women had experienced diabetes for nearly 2 more years on average when compared to White women, with an average time of 3.19 years. Smoking was seen in higher rates in the Native American population, with 37.8% (n=684) of the population smoking at least some days, with 46.6% (n=1148) of the Native American sample identifying as non-smokers.

Independent samples parametric (T-test and chi-squared) and non-parametric (Mann-Whitey U and Kruskal-Wallis) tests were performed to determine if there was a statistically significant difference between the White and Native American age-matched groups. Significant small effect differences were noted between groups in the variables BMI (t=10.35, Cohen's d = -0.24, 95% CI = -.286, -.194, p<0.001), years living with diabetes (t=11.32, Cohen's d = -0.328, 95% CI = -.372, -.283, p<0.001), and the number of children (t=14.16, Cohen's d = -0.391, 95% CI = -.0437, -.345, p<0.001). Mann-Whitney U testing was performed to examine rank sums between groups and significant differences were demonstrated between the White and Native American groups on variables related to income (p<0.001), general health (p<0.001), frequency of tobacco use (p<0.001), and healthcare cost (p<0.001).

Unsupervised Machine Learning

Based on the state of the science and previous literature, the following variables were trained into the k-means unsupervised machine learning algorithm for the White (training) and tested in Native American (test) samples: Mental Health, Age, General Health, Smoking, Diabetes, and BMI.

Unsupervised Machine Learning Training sample - White Women

Unsupervised machine learning in the training sample of white women indicated the best fit for the independent variables included in the algorithms was k-means = 6 with a 56.8% fit (Figure 1.a). Figure 1a represents the variance within the clusters for the White Women sample. Variance decreases as k increases, but it can be as a bend (or "elbow") at k = 6. This bend indicates that additional clusters beyond the sixth have little

value to explain the variance. Therefore, we grouped the white participants into six clusters demonstrating a fit of 56.8%. The White sample was divided into 6 clusters (cluster 1 *n*=1154; cluster 2 n=1972; cluster 3 n=761; cluster 4 n=937; cluster 5 n=288; cluster 6 n=2508). As shown in figure 1.b, cluster 5 emerged as the unique cluster of interest.

Unsupervised Machine Learning Test sample – Native American Women

Figure 2a represents the variance within the clusters for the Native American Women sample. It decreases while k increases, but it can be as a bend (or "elbow") at k = 6. This bend indicates that additional clusters beyond the sixth have little value to explain the variance. Therefore, we grouped the Native American participants into six clusters demonstrating a fit of 53.7%. The Native American sample was also divided into 6 clusters (cluster 1 n=277; cluster 2 n=519; cluster 3 n=517; cluster 4 n=298; cluster 5 n=639; cluster 6 n=213). As shown in figure 2.b, cluster 6 emerged as the unique cluster of interest.

Follow-up Analyses for Cluster Differences in Training and Testing Samples

To examine differences across clusters, ANOVA and Kruskal-Wallis H comparisons across clusters for each independent variable were examined in each the training (White) and testing (Native American) samples. As cluster 5 emerged as the cluster of interest in the White sample, Table 2 refects the group differences between cluster 5 and other clusters identified in the model. Kruskal-Wallis H was significant (p<0.001) for all variables. Assessing cluster 5 in the White sample, average time lived with diabetes was determined to be 23.79 years (*SD* 9.66) with Tukey's significant pair-wise comparisons indicating this cluster was significantly higher than the others

(p<0.001). The average BMI in cluster 5 was 32.22 (*SD* 8.11) with Tukey's significant pair-wise comparisons again indicating this cluster was significantly higher than the others (p<0.001).

In the testing Native American sample, cluster 6 emerged as the cluster of interest. In this sample, Kruskal-Wallis H was significant (p<0.001) for all variables (Table 3). Cluster 6, in particular, demonstrated average time lived with diabetes as 25.8 years (*SD* 9.8) with Tukey's significant pair-wise comparisons indicating this cluster was significantly higher than the others (p<0.001). The average BMI in cluster 6 was 31.04 (*SD* 6.06) with Tukey's significant pair-wise comparisons indicating a similar BMI in cluster 4 (29.59 *SD* 6.51), but cluster 6 had a significantly higher BMI than clusters 1, 2, 3, and 5 (p<0.001).

Discussion

After assessing fit with different predictor variables relevant to the development of OAB, the model chosen for White female respondents included the variables for mental health, age, general health, smoking, diabetes, and BMI. The fit for this model in White women was 56.8%. Looking at same model in Native American women, however, we found only a 53.7% fit, leading us to question if data from a sample of White women as good of a fit for Native American women?

As previously highlighted, there were a number of variables that showed significance when compared between groups and clusters. Unsurprisingly, because age-matched groups were utilized, significance was not noted regarding age. The mental health variable was also insignificant when determining risk factors for OAB, which was expected since we hypothesized that the direction of this correlation would be reversed,

with OAB being a risk factor for mental health sequelae. As expected, BMI, amount of time lived with diabetes, and number of children in the household did appear to correlate with the development of OAB across both races. Other factors that demonstrated significance included income, general health, smoking frequency, and healthcare cost.

While a diagnosis of depression was not a significant predictor ($p=0.019$), it is important to remember that historically, Native Americans have suffered higher rates of mental illness and death by suicide (NAMI, 2023; NCAI, 2020). The literature largely agrees that OAB can lead to mental health consequences, specifically depression and anxiety. Considering the Native American sample suffered from higher rates of other predictors for OAB, and had higher rates of poor mental health days (5.89, SD 9.61) when compared to the White sample (5.26, SD 8.67), it is imperative that mental health is not ignored in this population when presenting with OAB.

Results were largely consistent between the White and Native American samples; however, the Native American sample did report higher rates of predictive factors for OAB, including BMI, time lived with diabetes, number of children, lower income level, poorer general health, higher rates of smoking, and more likely to be uninsured and/or struggle with health costs (Table 1). The results support that the model trained in White women and tested in Native American women fit both groups, with similar risk factors impacting the risk of developing OAB in both races; however, the risk appears to be slightly higher in the White sample. The model was designed based on risk factors identified in the literature (Gramke et al., 2023 unpublished), however, items related to healthcare access and overall household income detracted from the model's fit. Post-hoc analyses including healthcare access and cost and annual household income reduced the

model's fit for both White and Native American with fits ranging from 47.1% to 52.6% (See Appendix A). As such, the models reported in the current study did not include these factors. This research supports the need for additional research in OAB for Native American populations to ensure etiological models are well-fit for that population.

After running a one-way ANOVA which demonstrated significance among all evaluated variables, a Tukey test was performed to assess whether the means were significantly different among clusters. Paying particular attention to cluster 5 in the White sample and cluster 6 in the Native American sample, it appears that certain variables may be driving the risk factors most related to the development of OAB. In both clusters (White cluster 5 and Native American cluster 6) these variables include BMI and years lived with diabetes, with a higher BMI and a higher number of years with diabetes being more strongly associated with the development of OAB.

Limitations

There were limitations in this study, most notably that BRFSS does not contain items related to OAB. However, the BRFSS has a large sample of Native Americans and a significant number of indicators related to risk factors for OAB, which was a strength to using this data set for the purposes of this study. Furthermore, the unsupervised machine learning approach allowed for novel investigation of predictive risk for OAB as no known studies have investigated risk factors for OAB in the Native American population. Although the BRFSS had a significant number of risk factors for OAB listed in the literature, there were some variables related to parity which limited our ability to assess the risk associated with parity for OAB. However, we were able to use number of children in the household and current pregnancy status as proxies. Future research should

include a comprehensive assessment of parity when examining health outcomes, particularly in diseases related to pelvic floor and female reproduction. Even with these limitations, this study is the first to our knowledge to examine potential risk for OAB in Native American women populations.

Future Directions and Implications

Future data collection should aim to be both descriptive and analytic and include a wider array of variables specific to women and women's health, specifically variables to gain insight into pregnancy history and overactive bladder as both of these affect large numbers of women. Mental health should also be examined more fully, with questions about specific mental health diagnoses being asked, rather than combining all diagnoses into one large, generic category. Further, a goal of research should be to include more Native Americans in these datasets and to ensure they are classified appropriately. By collecting a more holistic set of data, limitations in research can be reduced and the results obtained through the use of the data can be implemented more fully in practice.

There is currently a dearth of literature examining the mental health impact of OAB on Native American women. While research exists examining this relationship in other races of women, Native American women are rarely represented. Making matters worse, when they are included, it is generally just as a demographic statistic; however, findings are rarely broken down by race making it difficult to determine if race is a factor in the development of depression and anxiety subsequent to OAB.

By identifying key variables that appear to be significant in the development of OAB, providers are encouraged to screen for these issues in all women, specifically BMI, time lived with diabetes, parity, smoking frequency, and general health. Women who

demonstrate high rates of these variables should also be screened for OAB so that treatment can be offered. Those who screen positively for OAB should also have their mental health assessed to determine if depressive or anxiety symptoms are present so that they may be referred for psychiatric care, if necessary.

This research also highlights the importance of adequate funding to the Indian Health Service. As discussed above, Native American women have higher rates of preventable issues, such as obesity, diabetes, and smoking. Through preventative care, these issues could be mitigated which could lead to improved health and an increased quality of life.

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Table 1: Demographic Characteristics and Group Comparisons across Race

	Total (N=10,083)		White (n=7,620)		Native American (n=2,463)						
	M	***SD***	***M***	***SD***	***M***	***SD***	***t***	***df***	***p***	***Cohen's d***	***95% CI***
Age	51.18	16.55	51.00	16.71	51.75	16.04	2.00	4322.22	0.046	-0.045	(-.091- .000)
BMI	28.48	7.04	28.07	6.92	29.75	7.23	10.35	10081	<0.001	-0.24	(-.286- -.194)
Years Living with Diabetes (Total Sample)	1.70	6.06	1.21	5.13	3.19	8.13	11.32	3117.954	<0.001	-0.328	(-.372- -283)
# of days with low mental health	5.42	8.91	5.26	8.67	5.89	9.61	2.88	3841.799	0.004	-0.07	(-.116--.025)
# of Children	0.74	1.24	0.62	1.09	1.10	1.56	14.16	3281.924	<0.001	-0.391	(-.0437- -.345)
	N	***%***	***N***	***%***	***N***	***%***	***Mann-whitney U***		***p***		
Income							5,566,339.00		<.001		
< $10,000	508	5.00	208	2.70	300	12.20					
$10,000 to less than $15,000	478	4.70	261	3.40	217	8.80					
$15,000 to less than $20,000	757	7.50	420	5.50	337	13.70					
$20,000 to less than $25,000	933	9.30	604	7.90	329	13.40					
$25,000 to less than $35,000	983	9.70	708	9.30	275	11.20					
$35,000 to less than $50,000	1307	13.00	986	12.90	321	13.00					
$50,000 to less than $75,000	1616	16.00	1311	17.20	305	12.40					
> $75,000	3501	34.70	3122	41.00	379	15.40					
General Health							7,161,070.00		<.001		
Excellent	2037	20.20	1678	22.00	359	14.60					
Very Good	3646	36.20	3012	39.50	634	25.70					
Good	2858	28.30	2003	26.30	855	34.70					
Fair	1122	11.10	700	9.20	422	17.10					
Poor	420	4.20	227	3.00	193	7.80					
Frequency of tobacco smoke							7,654,854.00		<.001		
0 'non-smoker'	5846	58.00	4698	61.70	1148	46.60					
1 '10 years or more'	1380	13.70	1079	14.20	301	12.20					
2 'Within the past 10 years (5 years but less than 10 years ago)'	302	3.00	219	2.90	83	3.40					
3 'Within the past 5 years (1 year but less than 5 years ago)'	433	4.30	299	3.90	134	5.40					
4 'Within the past year (6 months but less than 1 year ago)'	116	1.20	79	1.00	37	1.50					
5 'Within the past 6 months (3 months but less than 6 months ago)'	69	0.70	49	0.60	20	0.80					
6 'Within the past 3 months (1 month but less than 3 months ago)'	59	0.60	36	0.50	23	0.90					
7 'within the past month (less than 1 month ago)'	77	0.80	44	0.60	33	1.30					
8 'somedays'	473	4.70	264	3.50	209	8.50					
9 'every day'.	1328	13.20	853	11.20	475	19.30					
Insurance coverage and health care financial problems							8,733,567.50		<.001		
1 'insurance coverage no cost problems'	8668	86.00	6683	87.70	1985	80.60					
2 'insurance coverage and YES cost problems'	798	7.90	514	6.70	284	11.50					
3 'no insurance coverage no cost problems'	390	3.90	246	3.20	144	5.80					
4 'no insurance coverage YES cost problems'.	227	2.30	177	2.30	50	2.00					
Time since last visited a doctor for a routine checkup?							9,293,443.50		0.306		
Never (0)	29	0.30	18	0.20	11	0.40					
Less that 1 year (1)	8013	79.50	6041	79.30	1972	80.10					
1-2 years	1214	12.00	944	12.40	270	11.00					
2-5 year	478	4.70	363	4.80	115	4.70					
> 5 Years	349	3.50	254	3.30	95	3.90					
							Chi-squared		***p***		
Depression diagnosis							5.47		0.019		
Yes	2801	27.80	2162	28.40	639	25.90					
No	7282	72.20	5458	71.60	1824	74.10					

Tables 2: Unsupervised Cluster Differences for White Women (*n* = 7620)

	Cluster 1		Cluster 2		Cluster 3		Cluster 4		**Cluster 5**		Cluster 6					
	M	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	***F***	***df***	***p***	***significant pair-wise comparisions***
Age	51.34	13.66	34.43	10.1	46.57	16.21	48.1	13.82	**63.66**	**12.45**	64.84	8.88	1602.85	(5, 7614)	<0.001	5=6; 5>1,2,3,4
BMI	37.86	6.57	24.52	3.9	29.47	7.22	27.27	6.05	**32.22**	**8.11**	25.75	3.83	1135.038	(5, 7614)	<0.001	5>1,2,3,4,6
Years Living with Diabetes (Total Sample)	0.75	2.39	0.03	0.54	0.63	2.47	0.38	1.85	**23.79**	**9.66**	0.26	1.45	4948.276	(5, 7614)	<0.001	5>1,2,3,4,6
# of days with low mental health	3.69	5.38	3.72	5.05	26.5	5.08	4.14	5.93	**5.18**	**9.01**	1.19	2.8	3349.644	(5, 7614)	<0.001	4=5; 5>1,2,6; 5 < 3
# of Children	0.61	1.07	1.19	1.34	0.66	1.1	0.76	1.12	**0.25**	**0.76**	0.15	0.55	244.078	(5, 7614)	<0.001	5 = 1,2,3,4,6
	N	***%***	***N***	***%***	***N***	***%***	***N***	***%***	***N***	***%***	***N***	***%***	***Kruskal-Wallis H***		***p***	
Income													647.079		<0.001	5=3,4; 5<1,2,6
< $10,000	27	2.3	32	1.6	49	6.4	54	5.8	**18**	**6.3**	28	1.1				
$10,000 to less than $15,000	56	4.9	31	1.6	48	6.3	53	5.7	**25**	**8.7**	48	1.9				
$15,000 to less than $20,000	72	6.2	57	2.9	65	8.5	88	9.4	**25**	**8.7**	113	4.5				
$20,000 to less than $25,000	91	7.9	89	4.5	97	12.7	122	13.0	**39**	**13.5**	166	6.6				
$25,000 to less than $35,000	110	9.5	106	5.4	90	11.8	117	12.5	**44**	**15.3**	241	9.6				
$35,000 to less than $50,000	147	12.7	208	10.5	97	12.7	124	13.2	**49**	**17**	361	14.4				
$50,000 to less than $75,000	223	19.3	330	16.7	115	15.1	141	15.0	**39**	**13.5**	463	18.5				
> $75,000	428	37.1	1119	56.7	200	26.3	238	25.4	**49**	**17**	1088	43.4				
General Health													2146.849		<0.001	5>1,2,3,4,6
Excellent	30	2.6	845	42.8	56	7.4	123	13.1	**3**	**1**	621	24.8				
Very Good	315	27.3	922	46.8	188	24.7	332	35.4	**53**	**18.4**	1202	47.9				
Good	544	47.1	197	10	257	33.8	335	35.8	**113**	**39.2**	557	22.2				
Fair	203	17.6	7	0.4	178	23.4	117	12.5	**84**	**29.2**	111	4.4				
Poor	62	5.4	1	0.1	82	10.8	30	3.2	**35**	**12.2**	17	0.7				
Frequency of tobacco smoke													3397.105		<0.001	5>1,2,3,4,6
0 'non-smoker'	758	65.7	1657	84	360	47.3			**161**	**55.9**	1762	70.3				
1 '10 years or more'	229	19.8	131	6.6	79	10.4			**65**	**22.6**	575	22.9				
2 'Within the past 10 years (5 years but less than 10 years ago)'	57	4.9	56	2.8	30	3.9			**8**	**2.8**	68	2.7				
3 'Within the past 5 years (1 year but less than 5 years ago)'	65	5.6	85	4.3	47	6.2	1	0.1	**11**	**3.8**	90	3.6				
4 'Within the past year (6 months but less than 1 year ago)'	19	1.6	27	1.4	13	1.7	10	1.1	**1**	**0.3**	9	0.4				
5 'Within the past 6 months (3 months but less than 6 months ago)'	5	0.4	15	0.8	9	1.2	16	1.7			4	0.2				
6 'Within the past 3 months (1 month but less than 3 months ago)'	3	0.3	1	0.1	11	1.4	18	1.9	**3**	**1**						
7 'within the past month (less than 1 month ago)'	3	0.3			12	1.6	28	3.0	**1**	**0.3**						
8 'somedays'	6	0.5			46	6	204	21.8	**8**	**2.8**						
9 'every day'.	9	0.8			154	20.2	660	70.4	**30**	**10.4**						
Depression diagnosis													861.414		<0.001	5=1,2; 5<2,6; 5>3
Yes	396	34.3	398	20.2	508	66.8	348	37.1	**104**	**36.1**	408	16.3				
No	758	65.7	1574	79.8	253	33.2	589	62.9	**184**	**63.9**	2100	83.7				
Insurance coverage and health care financial problems													297.885		<0.001	5=1,2,6; 5>3,4
1 'insurance coverage no cost problems'	991	85.9	1753	88.9	569	74.8	746	79.6	**249**	**86.5**	2375	94.7				
2 'insurance coverage and YES cost problems'	93	8.1	118	6	121	15.9	78	8.3	**33**	**11.5**	71	2.8				
3 'no insurance coverage no cost problems'	39	3.4	65	3.3	18	2.4	66	7.0	**4**	**1.4**	54	2.2				
4 'no insurance coverage YES cost problems'.	31	2.7	36	1.8	53	7	47	5.0	**2**	**0.7**	8	0.3				
Time since last visited a doctor for a routine checkup?													210.398		<0.001	5>1,2,3,4,6
Never (0)	2	0.2	7	0.4	3	0.4	3	0.3			3	0.1				
Less that 1 year (1)	981	85.0	1414	71.7	582	76.5	669	71.4	**274**	**95.1**	2121	84.6				
1-2 years	103	8.9	346	17.5	93	12.2	135	14.4	**12**	**4.2**	255	10.2				
2-5 year	44	3.8	124	6.3	45	5.9	67	7.2			83	3.3				
> 5 Years	24	2.1	81	4.1	38	5	63	6.7	**2**	**0.7**	46	1.8				

Tables 3: Unsupervised Cluster Differences for Native American Women (*n* = 2463)

	Cluster 1		Cluster 2		Cluster 3		Cluster 4		Cluster 5		**Cluster 6**					
	M	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	***F***	***df***	***p***	***Tukey's significant pair-wise comparisions***
Age	45.94	12.57	51.73	14.96	35.67	10.24	48.96	14.36	64.51	9.36	**63.97**	**10.01**	392.522	(5, 2457)	<0.001	6=5; 6>1,2,3,4
BMI	42.81	7.28	27.27	4.93	27.19	4.69	29.59	6.51	27.81	4.55	**31.04**	**6.06**	385.154	(5, 2457)	<0.001	6=4;6<1,2,3,5
Years Living with Diabetes (Total Sample)	1.91	4.27	0.81	2.73	0.23	1.37	1.81	4.63	1.16	3.2	**25.8**	**9.8**	1375.612	(5, 2457)	<0.001	6>1,2,3,4,5
# of days with low mental health	4.49	6.74	2.95	4.91	2.52	4.54	27.12	5.05	1.68	3.45	**5.97**	**9.68**	1088.728	(5, 2457)	<0.001	6=1; 6>2,3,5; 6<4
# of Children	1.34	1.62	1.18	1.62	1.62	1.57	1.08	1.58	0.65	1.36	**0.67**	**1.31**	28.516	(5, 2457)	<0.001	6 = 4,5; 6<1,2,3
	N	***%***	***N***	***%***	***N***	***%***	***N***	***%***	***N***	***%***	***N***	***%***	***Kruskal-Wallis H***		***p***	
Income													123.304		<0.001	6=1,2,4; 6<3,5
< $10,000	35	12.6	71	13.7	40	7.7	59	19.8	66	10.3	**29**	**13.6**				
$10,000 to less than $15,000	23	8.3	50	9.6	25	4.8	42	14.1	49	7.7	**28**	**13.1**				
$15,000 to less than $20,000	38	13.7	93	17.9	50	9.7	41	13.8	79	12.4	**36**	**16.9**				
$20,000 to less than $25,000	43	15.5	76	14.6	55	10.6	42	14.1	80	12.5	**33**	**15.5**				
$25,000 to less than $35,000	35	12.6	56	10.8	66	12.8	21	7.0	70	11	**27**	**12.7**				
$35,000 to less than $50,000	31	11.2	57	11	74	14.3	35	11.7	95	14.9	**29**	**13.6**				
$50,000 to less than $75,000	37	13.4	56	10.8	78	15.1	36	12.1	81	12.7	**17**	**8**				
> $75,000	35	12.6	60	11.6	129	25	22	7.4	119	18.6	**14**	**6.6**				
General Health													610.739		<0.001	6=4;6>1,2,3,5
Excellent	6	2.2	79	15.2	191	36.9	9	3.0	68	10.6	**6**	**2.8**				
Very Good	42	15.2	167	32.2	180	34.8	44	14.8	179	28	**22**	**10.3**				
Good	133	48.0	175	33.7	134	25.9	81	27.2	273	42.7	**59**	**27.7**				
Fair	76	27.4	75	14.5	12	2.3	98	32.9	83	13	**78**	**36.6**				
Poor	20	7.2	23	4.4			66	22.1	36	5.6	**48**	**22.5**				
Frequency of tobacco smoke													1307.806		<0.001	6=1; 6<2,4; 6>3,5
0 'non-smoker'	122	44.0			413	79.9	108	36.2	399	62.4	**106**	**49.8**				
1 '10 years or more'	40	14.4			33	6.4	27	9.1	158	24.7	**43**	**20.2**				
2 'Within the past 10 years (5 years but less than 10 years ago)'	14	5.1			16	3.1	15	5.0	31	4.9	**7**	**3.3**				
3 'Within the past 5 years (1 year but less than 5 years ago)'	33	11.9			30	5.8	19	6.4	39	6.1	**13**	**6.1**				
4 'Within the past year (6 months but less than 1 year ago)'	6	2.2			15	2.9	5	1.7	9	1.4	**2**	**0.9**				
5 'Within the past 6 months (3 months but less than 6 months ago)'	1	0.4	6	1.2	6	1.2	2	0.7	3	0.5	**2**	**0.9**				
6 'Within the past 3 months (1 month but less than 3 months ago)'	6	2.2	10	1.9	3	0.6	4	1.3								
7 'within the past month (less than 1 month ago)'	2	0.7	23	4.4			6	2.0			**2**	**0.9**				
8 'somedays'	23	8.3	148	28.5	1	0.2	29	9.7			**8**	**3.8**				
9 'every day'.	30	10.8	332	64			83	27.9			**30**	**14.1**				
Depression diagnosis													317.311		<0.001	6=1,2; 6<3,5; 6>4
Yes	92	33.2	123	23.7	78	15.1	192	64.4	91	14.2	**63**	**29.6**				
No	185	66.8	396	76.3	439	84.9	106	35.6	548	85.8	**150**	**70.4**				
Insurance coverage and health care financial problems													42.378		<0.001	6=1,2,3,5; 6<4
1 'insurance coverage no cost problems'	230	83.0	402	77.5	420	81.2	206	69.1	550	86.1	**177**	**83.1**				
2 'insurance coverage and YES cost problems'	29	10.5	60	11.6	42	8.1	65	21.8	59	9.2	**29**	**13.6**				
3 'no insurance coverage no cost problems'	11	4.0	43	8.3	48	9.3	12	4.0	28	4.4	**2**	**0.9**				
4 'no insurance coverage YES cost problems'.	7	2.5	14	2.7	7	1.4	15	5.0	2	0.3	**5**	**2.3**				
Time since last visited a doctor for a routine checkup?													50.564		<0.001	6=1,5; 6<2,3,4
Never (0)	2	0.7	2	0.4	4	0.8			3	0.5						
Less than 1 year (1)	224	80.9	403	77.6	375	72.5	233	78.2	535	83.7	**202**	**94.8**				
1-2 years	28	10.1	52	10	86	16.6	33	11.1	63	9.9	**8**	**3.8**				
2-5 year	15	5.4	32	6.2	29	5.6	19	6.4	17	2.7	**3**	**1.4**				
> 5 Years	8	2.9	30	5.8	23	4.4	13	4.4	21	3.3						

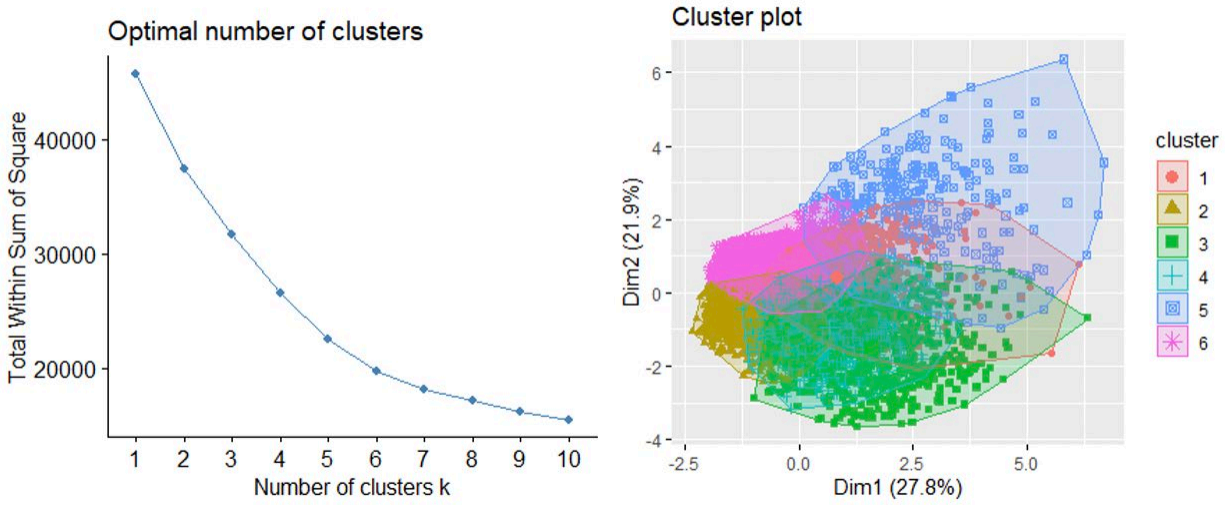

Figure 1. *Unsupervised Machine Learning Clustering Data White Sample (N=7620) with Variables Mental Health, Age, General Health, Smoking, Diabetes, and BMI;*
(between_SS / total_SS = 56.8 %)

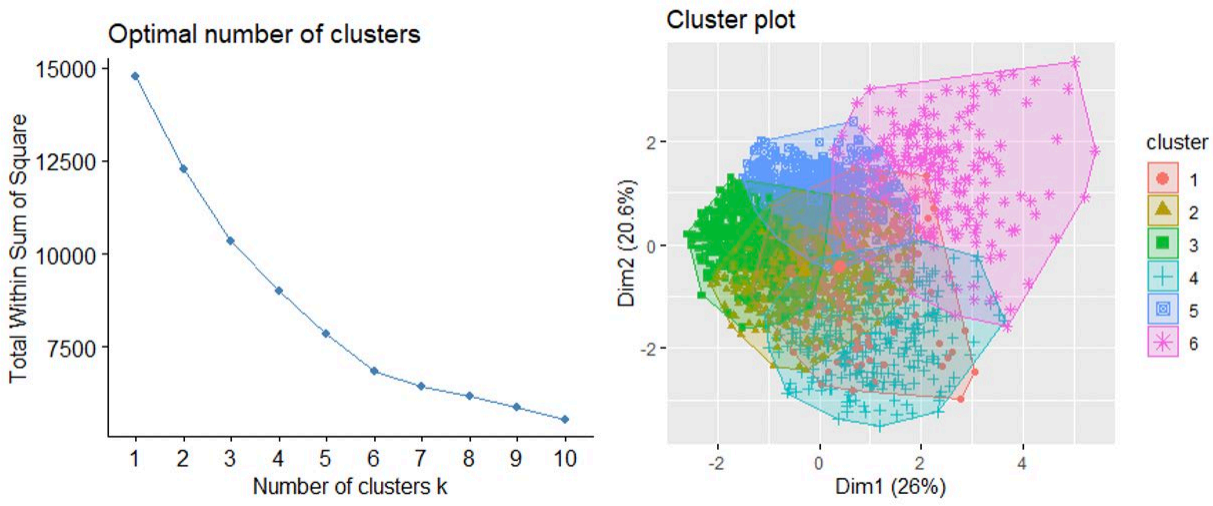

Figure 2. *Unsupervised Machine Learning Clustering Data Native American Sample (N=2463) with Variables Mental Health, Age, General Health, Smoking, Diabetes, and BMI;* (between_SS / total_SS = 53.7 %)

Chapter 5

Conclusion

Pelvic floor dysfunction is a prevalent, expensive, and life-altering problem affecting millions of women in the United States alone. Despite the social, economic, and health-related burdens resulting from this disorder, the majority of women who suffer do not seek, or are not offered, treatment for the associated symptoms (Duralde et al., 2016; Lukacz et al., 2017). Making matters worse, there is a dearth of Native American subgroup analysis in the research currently available on this disorder, leading clinicians to rely on data that has been largely obtained through the study and evaluation of White women.

What has been Learned

Through the research conducted for this dissertation, it has become clear that poor access to healthcare, an issue that is most prevalent in the Native American population, can lead to an increased probability of developing risk factors associated with pelvic floor dysfunction. This disorder increases one's risk of mental health sequelae, specifically depression and anxiety which, in turn, are known to decrease the overall quality of life. Native American women suffer from higher rates of disorders and lifestyle habits associated with the development of pelvic floor dysfunction, in particular obesity, diabetes mellitus, and smoking which, theoretically puts them at higher risk for the development of this disorder and its resulting consequences.

Implications

Practice

As evidenced by the literature currently available on the subject of pelvic floor dysfunction, providers are not currently meeting the needs of women suffering from this disorder. With diagnostic and treatment rates for the disorder as low as 25%, providers must ensure that all women are evaluated for pelvic floor dysfunction due to the high prevalence rate and poor outcomes of this disorder if left untreated. Those women who screen positive for pelvic floor dysfunction should then be screened for depression and anxiety. Referrals to mental health treatment should then be made, as appropriate.

Barriers to care must be evaluated more comprehensively and addressed. For example, it is important to consider the necessity of culturally competent providers in the treatment of Native Americans. Clinicians should prioritize improving their ability to provide culturally competent care to Native Americans in an effort to decrease this barrier to healthcare. Clinicians should also identify ways in which Native Americans who live in more remote areas can access specialty care for issues such as pelvic floor dysfunction.

Policy

As discussed in Manuscripts 1 and 2, underfunding of the Indian Health Service has contributed to an increased probability of Native American women developing risk factors for pelvic floor dysfunction. Improving access to care through adequate funding of the Indian Health Service has the potential to decrease the odds of Native American women developing these risk factors. Through the reduction of obesity, diabetes mellitus, and smoking, the risk of developing not only pelvic floor dysfunction, but the associated mental health sequelae as well, the overall quality of life of Native American women would likely be improved.

Research

This work highlights the need for more research, generally, to be conducted in Native American women. Too often, assumptions are made about the care of women of color based on research that has been done on a majority-White population. In order to meet the unique needs of non-White populations, research must be conducted examining issues specific to these populations to ensure the highest quality of care and improved outcomes. Furthermore, large scale epidemiologic data collection such as the Behavioral Risk Factor Surveillance System, discussed and utilized in Manuscript 3, should include more questions about health issues that impact large groups of women, such as pelvic floor dysfunction and its associated symptoms.

In order to best serve Native American women, future research should be conducted examining not only prevalence rates of pelvic floor dysfunction and its consequences, but their treatment preferences, and the efficacy of these treatments, as well. As previously discussed, some Native Americans may prefer more holistic types of treatment, so it is crucial to determine their preferences for the management of pelvic floor dysfunction.

Overall Contribution to Science

Native American women are understudied and underrepresented in research, and racial misclassification further augments their lack of visibility in research. This dissertation focuses specifically on this population of women and highlights] important areas of future study. The research on this topic conducted up to this point has focused largely on White populations, leaving clinicians and researchers to make inferences about the care of Native Americans that may or may not be correct, which can significantly

decrease quality of care and overall health outcomes in this population, and non-White populations in general.

Through the research conducted for the purposes of this dissertation, it has become clear that Native American women are likely at a higher risk of developing pelvic floor dysfunction and its consequences, including depression and anxiety. In order to best serve this population, this work could be expanded in the future to examine the issue more fully, including screening, diagnosis, and the culturally competent treatment of the disorder.

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