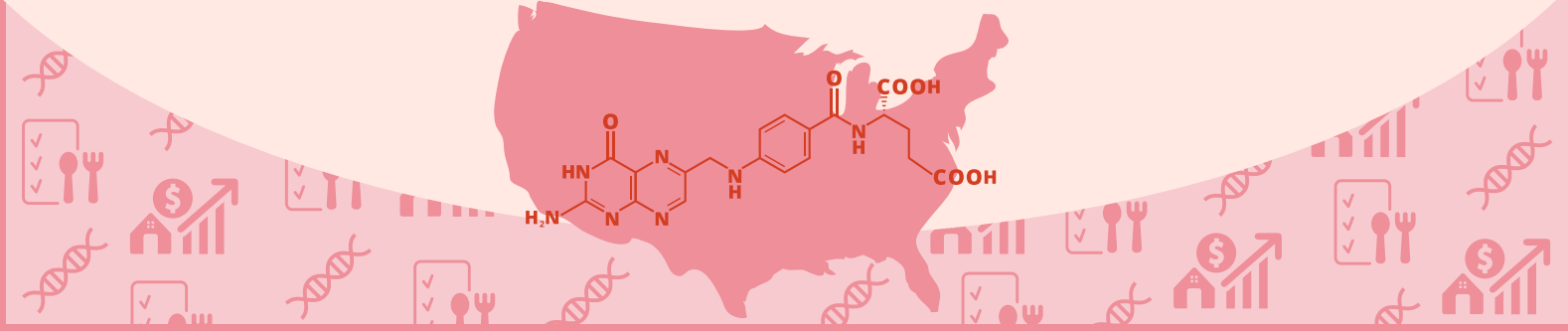

DELVING INTO THE DISPARITY: EXPLORING HIGH RATES OF SPINA BIFIDA IN HISPANIC COMMUNITIES IN THE UNITED STATES AFTER THE 1998 FOLIC ACID FORTIFICATION PROGRAM

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ABSTRACT

Background: Spina bifida (SB) is a congenital defect surrounding the development of the spine and spinal cord leading to neurological impairments, influenced by insufficient folic acid (FA) during gestation. Despite the U.S.'s implementation of a FA fortification program in 1998 to reduce the incidence of SB, there continues to be a discrepancy in SB rates between. Hispanic communities and non-Hispanic communities in the nation, highlighting a need for further exploration.

Objective: This paper explores the factors that contribute to the disproportionately high prevalence of SB in Hispanic communities as compared to the general population in the U.S. after the 1998 fortification program.

Methods: A literature review was conducted to assess the disparity in SB prevalence among ethnic groups in the U.S. post-1998, focusing on genetic, socioeconomic, and dietary factors.

Results: Analysis of the retrieved literature revealed that the combined effects of genetic, socioeconomic, and dietary factors correlated with a higher prevalence of spina bifida in Hispanic communities as opposed to non-Hispanic communities. Genetic studies highlighted elevated frequencies of the Methylenetetrahydrofolate reductase (MTHFR) gene variants in Hispanic populations. Additionally, socioeconomic disparities and dietary habits underscored challenges in the intake of folic acid and accessibility to fortified foods.

Conclusion: The findings in this paper support the following recommendations to help reduce the disproportionately high prevalence of spina bifida in Hispanic communities by; a) expanding the mandatory FA fortification program to include more products that are consumed by the Hispanic community and b) increasing community education about FA fortification.

INTRODUCTION

Spina bifida (SB) is a congenital disorder, and a type of neural tube defect (NTD), characterized by failed closure of the embryonic neural tube. The disorder encompasses myelomeningocele, meningocele, and spina bifida occulta. These vary greatly in regards to embryological development and prognosis. Myelomeningocele, which is the most common and most severe form of SB, is defined by an open spinal cord with a meningeal cyst. Meningocele refers to the protrusion of the meninges (filled with cerebrospinal fluid) through a defect in the skull or spine. SB occulta is a closed asymptomatic NTD in which some vertebrae are not completely fused. The symptomatology of SB varies greatly between cases, but it often causes individuals to exhibit motor and sensory neurological deficiencies below the level of the lesion. This can cause lower limb weakness, paralysis, lack of sensation, and urinary and fecal incontinence. SB is known to have a multifactorial inheritance, including numerous genetic and environmental risk factors, such as maternal substance use, maternal diet, geographic location, and certain demographic traits [1].

In 1996, the United States became the first country to introduce a FA fortification mandate to decrease the incidence of NTDs among its population. As of 2020, 72 countries have followed suit to implement FA fortification due to its success in United States [3]. The United States Food and Drug Administration declared that by January 1998, all grain cereal products on shelves across the nation be fortified with FA [3]. Findings from numerous papers that studied this intervention provide evidence that prenatal folic acid deficiency is a risk factor in the development of SB [4]. For instance, one population-based study investigated over 5000 NTD cases between 1995 and 1999 in 24 populations across the United States, calculating the prevalence of SB for births before and after the introduction of the 1998 FA fortification mandate. The study found a 31% decrease

[0.61 prevalence ratio] in cases, with a 95% confidence interval, reporting a temporal association between maternal prenatal FA intake and the prevalence of fetal SB development [5].

Hispanic refers to a person with ancestry from a country whose primary language is Spanish. Whereas, Latino, and its variations Latina and Latinx, refer to a person with origins from anywhere in Latin America [6]. There is no standard to how these terms are used within a research setting, for example, the Census Bureau now incorporates both as one category: "Hispanic or Latino" [7]. This paper will interpret the results of various studies using Hispanic and Latino as interchangeable terms, employing them as derived from their original publications.

Trends post-fortification in the period of 1999 to 2004 revealed that Hispanic infants had the smallest decrease in prevalence of neural tube defects (8%), in contrast to non-Hispanic White infants (11%) and non-Hispanic Black infants (14%) [8]. Furthermore, the prevalence of SB for Hispanic infants is currently reported to be the highest in the nation [9].

This article aims to explore contributing factors to the disproportionately high prevalence of SB in Hispanic communities as compared to the general population in the United States after the FA fortification program came into effect in 1998.

METHODS

A non-systematic literature search was conducted on relevant databases including PubMed, MEDLINE, Web of Science, and Cochrane. As well, grey literature from search engines (mainly Google and Google Scholar) were reviewed. In our search we employed Boolean operators and truncation features, with key search terms including, but not limited to: Hispanic, Latin, neural tube defects, spina bifida, and FA fortification. The populations of included papers had to have subgroups of Hispanics and/or Latino individuals. Additionally, the time frame of included articles was limited to those published in or after the year 1998 to eliminate studies that investigated SB prevalence before the implementation of the American folic acid fortification program. The outcome of interest was SB incidence. From the literature search, three prevalent themes were identified; genetic factors, maternal diet, and socioeconomic status. The connection between these three factors and SB will be further explored in this paper.

RESULTS

Genetic Factors

The disproportionately high prevalence of SB in Hispanic communities as compared to the general population in the United States may be partly attributed to genetic factors.

SB is known to have a multifactorial polygenic etiology, meaning that multiple genetic pathways are implicated in the development of the disorder [10]. The Methylenetetrahydrofolate reductase (MTHFR) gene is one such example and is involved in the creation of the MTHFR protein, which is important in folate metabolism [11]. Certain variants of the MTHFR gene are associated with an increased risk of NTD development, as they decrease the activity of the MTHFR protein [12]. For instance, the MTHFR C677T polymorphism results in a substitution mutation of cytosine for thymine at nucleotide 677, which alters the consequent amino acid from alanine to valine [13]. This missense mutation has functional consequences, reducing the activity of the MTHFR protein in folate metabolism [14].

Additionally, a review by Sharp and Little (2004) highlights the role of folate metabolism and MTHFR gene variants in various populations. Notably, U.S. Hispanics exhibit a higher prevalence of the TT genotype, a genotype that leads to decreased folate metabolism, as compared to African American and Caucasian populations [13].

The MTHFR C677T mutation varies in prevalence across different ethnic populations. A 2015 study with more than 1000 participants from across the United States reported that Hispanic Americans had the highest observed 677T allele frequency (42%), as compared to African Americans (16%) and Caucasian Americans (32%) [15]. These genetic differences correlate with the increased risk of NTD development amongst the Hispanic-American population [16].

Maternal Diet

Maternal diet, particularly concerning folic acid consumption, plays a crucial role in preventing NTDs, such as SB, including in Hispanic communities in the United States [17].

FA is known to significantly reduce the risk of SB when consumed before conception and during early pregnancy. However, due to dietary habits and disparities in prenatal education, insufficient FA consumption is particularly prevalent among Hispanic communities in the United States. Insufficient FA consumption may contribute to higher rates of SB in these populations may contribute to higher rates of SB in these populations [18].

Dietary preferences and habits of Hispanic populations reinforce the decreased impact of the 1998 FA fortification program on these communities.8 Though the United States government has mandated the fortification of cereal and some grain products with FA and successfully reduced the incidence of NTDs [16], these foods are not tailored to the diets of Hispanic communities. For instance, Hispanic diets are often

dominated by corn-based products, as opposed to flour-based products, meaning they do not benefit from the FA fortification mandate to the same extent as the general population [19].

While introducing FA fortification in cereal is economically viable, due to its low cost per calorie and edible gram [20], it may have disproportionately benefited one culture's dietary intake as opposed to another. As reported by qualitative interviews with several Hispanic women from nine countries of origin living in the United States, Hispanic women's criterion for purchasing food is primarily based on familial preference [21]. As aforementioned, Hispanic communities tend to prefer corn-based products over flour-based foods [20]. This could justify the decreased impact observed in Hispanic communities after the advent of FA fortified cereals in 1998 [8].

Furthermore, access to health information likely impacts the understanding of the importance of FA consumption and prenatal care among Hispanic women [18]. Surveys of women aged 18-45 found that, as compared to Non-Hispanic White women, non-White Hispanic women had lower awareness of the importance of FA intake on preventing spina bifida [17,18,22-25]. A national survey of 1685 non-pregnant women in the United States analyzed the ethnicities of the women consuming the suggested 400 µg daily dose of FA through fortified foods and found that only 6.8% of Hispanic women met this recommendation, as compared to 8.9% of non-White Hispanic women [23]. Furthermore, when including nutritional supplements in daily intake measurements, still only 21% of Hispanic women consumed the recommended 400 µg FA, as compared to 40.5% of non-Hispanic white women [23]. These intake disparities may be attributed to the combined impacts of dietary preferences and educational inequities within the Hispanic community.

Socioeconomic Factors

Socioeconomic status (SES) is a way of describing one's educational attainment, income, and occupational prestige and is consistently correlated to an array of psycho-social and biological outcomes [26]; SB and other NTDs are not an exception to this commonality [27]. Hispanic communities on average have lower socioeconomic status (SES) than other ethnic communities within the United States, which could explain certain aspects of the disparity in SB prevalence between these groups. For instance, Hispanic households traditionally have a smaller median income than White households [28]. Furthermore, 33% of Latino youth are currently living in poverty, as compared to a 14% poverty rate for non-Latino youth [29].

Within the past 20 years, there has been a decline in studies that look at the effect of SES on SB prevalence in Hispanic populations. In particular, one study conducted in San Joaquin Valley determined that acculturated neighbourhoods were a protective factor in preventing NTD prevalence. Acculturated neighbourhoods are defined as those with a higher proportion of US citizens, greater English proficiency and a lower Hispanic population. There was an association between non-acculturated neighbourhoods and inhalable polluted particulate matter, whereas no association was observed in acculturated neighbourhoods. Furthermore, there was a correlation between NTD prevalence and non-acculturated neighbourhoods [30]. This points to a lack of data surrounding this topic and a call to action from the authors to generate more research to further establish the correlation between SES and SB prevalence.

DISCUSSION

An analysis of the association of genetic factors, maternal diet, and socioeconomic factors with SB prevalence within Hispanic and non-Hispanic communities in the United States provides a comprehensive overview as to why the former population has disproportionately high rates of SB when compared to the general population. The MTHFR C677T polymorphism – a common mutation of the MTHFR gene – is shown to be associated with the development of NTDs such as SB and is known to be more common in Hispanic American populations. Insufficient FA consumption in Hispanic communities in the United States due to cultural dietary preferences and educational disparities contributes to higher rates of SB despite the government's fortification efforts. SES's correlation with SB, an understudied subject in recent years, shows a greater prevalence with a lower SES due to factors such as neighbourhood characteristics and culture.

Taking into account the current factors that affect SB prevalence in the Hispanic population, this paper encourages the American government to explore interventions that address these disparities. One approach is to mandate FA fortification in foods that consider the diet of the Hispanic population. Currently, the United States FA fortification program mandates that cereal grain products be fortified; including bread, pasta, rice, and cereal [31]. As stated previously, Hispanic women's criterion for purchasing food is according to familial preference, and thus, typical Western foods that are fortified with FA may not be purchased [21]. Interestingly, to address the disparity found in Hispanic populations, the United States added voluntary FA fortification in corn masa flour in 2016 [31]. However, a study by Wang et al. shows that there was not a significant difference in the risk of NTDs amongst the Hispanic population after the introduction of this policy [32]. Investigating this further, Kancherla et al. found that implementing voluntary FA fortification did not achieve widespread popularity amongst corn masa flour brands [33]. The researchers received photos of 43 corn masa flour products from participants across 28 states and found that only 3 included FA. Additionally, zero corn tortilla products were fortified [33]. This presents a

clear gap in the policy implemented by the United States government. Voluntary fortification has yet to have the intended effect on the Hispanic population, which may be due to the lack of culturally appropriate products that have FA fortification. In fact, this global systematic review identified the greatest reduction in NTD prevalence in Chile and Costa Rica after mandating FA fortification in all corn masa flour products. This significant reduction in Chile and Costa Rica was a 50% and 68% decrease, respectively, in NTD prevalence amongst Latinx communities [34]. However, it is also crucial to ensure that FA fortification of foods is regulated to adequately impact the intended target. The unregulated FA fortification program in Mexico resulted in 9-33% of women of child-bearing age consuming insufficient FA while 12% of children had an intake of FA above the tolerable limit [35], and the insufficient standards for fortification in Peru did not have an impact on NTD incidence [36]. Thus, the United States can explore a FA fortification mandate in corn masa products, similar to that of cereal grains, which is evidenced to have significantly decreased NTD prevalence amongst the general population. Thus, the United States can explore a FA fortification mandate in corn masa products, similar to that of cereal grains, which is evidenced to have significantly decreased NTD prevalence amongst the general population.

Fortifying commonly consumed foods can be applied to products that are utilized across all cultures, one of the most common ones being salt. This has been previously successful in preventing goitres in American populations by simply adding iodine to all salts [37]. Food nanotechnology and chemical engineering studies conducted in Canada have successfully created salt that can impart the recommended amount of folate (Vitamin B9) in iodized salt without affecting the flavour, colour, or sensory properties of the salt and remaining cost-effective [38,39].

An intervention that could be explored is to increase the awareness of FA supplementation among Hispanic populations. For example, there is a disproportionately larger proportion of Hispanic individuals from a lower socioeconomic status [28]. Further, Hispanic women have been found to have less prenatal education [18]. Furthermore, health education materials and outreach efforts may not always be culturally or linguistically tailored to effectively reach these communities [40]. A study conducted by deRosset et al. used the promotora de salud model to encourage the use of FA supplementation amongst Hispanic women in North Carolina [17,41]. This model leverages community health workers to support the health of Latinx community members. These workers can help provide information about FA, its importance, and address any barriers associated with having FA in the diet or via supplementation. This approach can ensure that culturally competent information is provided to members and leverages the existing trust between mothers and community health workers. The study showed a significant increase in FA supplement consumption between the baseline characteristics and at the 4-month follow-up. This provides support for the use of this model in encouraging the use of FA consumption in a culturally competent manner among the Hispanic population.

Although the Hispanic population has a disproportionately higher prevalence of SB, there are several interventions - such as making FA fortification mandatory for certain cultural foods and leveraging the promotora de salud model (a model that utilizes community identified leaders with shared social, cultural, and economic characteristics as community health workers)[17] - that the United States of America government can explore. This can lead to improved maternal and infant health outcomes and help narrow the disparities that exist in perinatal health among Hispanic communities. It is also important to engage with the Hispanic community to ensure that interventions are informed by their opinions. Thus, we also suggest future participatory action research studies to ensure bidirectional crosstalk between policymakers and the target communities [42].

LIMITATIONS

This paper has several limitations. Firstly, due to the paucity of research specifically pertaining to SB, many articles used in this review investigated the prevalence of NTDs overall. This is a limitation, as there are other NTDs beyond SB, such as encephalocele; therefore, the prevalence may not have been fully specific to SB. Future research may attempt to find SB specific prevalence data, or to potentially explore SB specific data. Additionally, as mentioned in the paper's introduction, the definition of the target population may not be comprehensive or may be overinclusive due to discrepancies between journals on the delineation of the Hispanic population. Furthermore, many articles included in this review used 'self-identification of ethnicity' as a method for assigning participants to research groups, which may result in inaccurate or inconsistent characterization of the target population. Further research may want to further investigate the extent of how "self-identification" may influence results, or to find research that does not rely on "self-identification." This could also contribute to the lack of insights from the Hispanic and Latinx communities. Their insights would be essential to learn from their own lived experiences. Future research endeavors should investigate the perspectives of Hispanic and Latinx communities.

CONCLUSION

The findings of this paper highlights genetic factors, maternal diet, and socioeconomic influences that contribute to the disproportionately high rates of SB in Hispanic communities compared to non-Hispanic

communities in the United States. To address this health disparity, our research advocates for the expansion of mandatory FA fortification programs to encompass more products that are consumed by the Hispanic community. In addition, targeted community education about FA is recommended. Future research should prioritize the implementations of Hispanic communities perspectives, such as through participatory action research studies. Such an approach ensures that communities are involved with identifying the issues and are actively involved in the creation of culturally relevant programs that can address the observed discrepancy in SB prevalence. It is essential to gain their perspectives, such as through participatory action research studies. Such an approach ensures that communities are involved with identifying the issues and are actively involved in the creation of culturally relevant programs that can address the observed discrepancy in SB prevalence.

KEY MESSAGES

- Hispanic communities in the United States experience disproportionately high prevalence of spina bifida.
- Genetic factors, maternal diet, and socioeconomic factors are all associated with higher prevalence of spina bifida in the Hispanic communities.
- Expansion of folic acid fortification program to more products and community education about the importance of FA are ways to address the disparity in spina bifida prevalence.
- Future studies should adopt a participatory action approach to help identify and address the challenges faced by Hispanic communities in relation to spina bifida.

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