Pellagra: A Biocultural Perspective

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Introduction

Pellagra is a niacin deficiency disease that is usually endemic among indigent populations around the world, and is thus a disease of undernutrition and social inequality. The emergence of the disease is concurrent with the domestication of corn, and is generally associated with a high maize and low protein diet (Brenton, 2000). In addition, pellagra has been of a popular interest to nutritional anthropologists because of its numerous social implications. A brief discussion of pellagra’s social history and biochemistry will follow an examination of its pathology and etiology. Furthermore, a cross-cultural analysis of pellagra from an anthropological stance will be explored more fully by way of incorporating a biocultural model. By examining pellagra from a biocultural perspective, one is able to apply a holistic approach to better understand how the biological, cultural, and environmental complexities affect those that suffer from the disease.

Pathology and Etiology

Pellagra translates literally as “rough or angry skin” (Brenton, 1998:1). Pellagra is classified as having the four D’s syndrome: dermatitis, diarrhea, dementia, and death. Other symptoms may include glossitis, or fiery red tongue, chronic weakness, high sensitivity to light, and weight loss. Chronic dementia is seen only in severe acute cases of pellagra. Otherwise, mental changes may present themselves in the form of mild depression. Depressive states are most likely due to the decreased ability to synthesize 5-hydroxytryptamine, or 5-HT, in the brain, which is only produced by the amino acid tryptophan (Davidson et al., 1975). The relation of tryptophan to pellagra will be further discussed in the biochemistry portion of this paper. Moreover, the skin often suggests
diagnosis of pellagra since it resembles severe sunburned lesions, especially around the forearms, wrists, backs of the hands, face, and neck. Furthermore, chronic gastritis in the form of diarrhea often induces watery and bloody stools for pellagrins, or those that are afflicted with pellagra. For women, vaginitis and amenorrhea are likely to occur as well. Pellagra is also found in some cases of alcoholism. Treatment of pellagra consists of specific vitamin therapy, most notably nicotinamide and nicotinic acid, and a high protein diet. Within twenty-four hours after the absorption of nicotinamide, symptoms of pellagra are almost immediately ameliorated, granted that there is a steady diet of quality protein such as eggs, meat, and fish (Davidson et al., 1975). Pellagra can be immuno-suppressant as well, which could ultimately lead to an onset of infectious diseases (Brenton, 1998).

Several etiological theories have been proposed throughout history to account for the high prevalence of pellagra. After the discovery of bacteria in the nineteenth century, some scientists believed that pellagra was due to bacterial toxins in maize, most likely produced from fermentation during storage of the crop. A century later, some argued that protein deficiency was the root cause of the disease since many individuals exhibited an insufficient intake of protein (Davidson et al., 1975). Yet others attributed the cause of pellagra to eugenics, contaminated grains, heredity, or insects (Brenton, 2000). Unanswered questions from the above theories led to the discovery of the preventative factor of pellagra, nicotinic acid, which is a heat-soluble, non-protein factor extracted from yeast and liver (Davidson et al., 1975). Joseph Goldberger’s studies during the twentieth century in the southern United States have revealed more knowledge about pellagragenic factors, and will be discussed in greater detail in the biocultural
explanations of pellagra. The most recent and widely accepted etiological theory of pellagra is an inhibition of tryptophan to niacin conversion, which can be the result of decreased bioavailability of both niacin and/or tryptophan (Brenton, 1998).

Social History

Western physicians first recognized pellagra in the eighteenth century after maize was introduced into Europe from the New World. Maize soon became a staple crop in Italy and Spain with popular cuisines such as polenta. Eventually, pellagra became known to as the “plague of corn” in marginalized populations of Europe, affecting primarily poor peasants (Brenton, 2000). Pellagra spread to the southern United States after the Civil War, and remained prominent until the beginning of the Second World War. Additionally, the Bantu of South Africa had a high prevalence of pellagra in 1897 because of their reliance on maize paps after a rinderpest outbreak of their cattle, disallowing milk production and consumption. Today, pellagra is found in India, in which maize is a staple cereal. Also, pellagra has been seen in sorghum consumers in Hyderabad, India, primarily because of sorghum’s high content of leucine (Davidson et al., 1975). The effects of leucine on pellagra can better be understood in the biochemistry section. Further investigation of European, American, and African incidences of pellagra will be discussed from a biocultural perspective later.

Biochemistry

It is essential to understand the biochemical constituents related to pellagra, and ultimately maize processing techniques before analyzing the biocultural implications of the disease. As previously mentioned, pellagra is a niacin deficiency disease. Niacin,
also known to as nicotinic acid, is a member of the B-complex vitamins, most notably the B3 vitamin. Tryptophan is an essential amino acid, and is also a precursor to niacin (Katz et al., 1974). In addition, niacin is important in cellular metabolic processes because niacin is a precursor to the coenzymes NAD (nicotinamide adenine dinucleotide) and NADP (nicotinamide adenine dinucleotide phosphate). Thus, when there is a niacin deficiency within the body, there are decreased levels of NAD and NADP, which thus inhibit several important cellular processes from occurring (Brenton, 1998). Foods that contain niacin are meats, fish, liver, eggs, legumes, nuts, many fruits and vegetables, and whole grain products (Carpenter and Lewin, 1985).

Maize is quite nutritionally deficient of essential amino acids tryptophan and lysine, as well as niacin. However, corn contains a high molecular weight of glutelin, a heterogeneous protein that is found within the germs and endosperms of corn kernels. Glutelin is indigestible to humans, and contains approximately two-thirds of the lysine found within corn kernels. Thus, increasing the availability of lysine found within corn would increase corn’s nutritional value. Furthermore, leucine and isoleucine are also essential amino acids. Having excessive amounts of leucine within the body is thought to cause an inhibition of tryptophan to niacin, and thus inducing pellagra. However, a higher ratio of isoleucine to leucine can counteract this reaction from taking place, and thus preventing pellagra from transpiring (Katz et al., 1974).

Biocultural Explanations of Pellagra

Katz et al. (1974) asserts that the agricultural revolution of domesticating corn has led to shifts in diet, technological advancements, increases in population sizes, as well as changes in social and cultural organizations. Furthermore, maize has an important
dietary role in Mesoamerican culture since it is the largest source of calories and protein for people in Central America. However, Mesoamerican civilizations, like the Ancient Maya, did not experience an onset of pellagra, even though some degree of malnutrition probably existed with dependence on one staple crop. Mesoamerican societies use an alkali processing technique with either lime, lye or wood ash when preparing their maize-based foods in order to allow for better nutritional absorption, which in turn protects them against pellagra. By using the lime technique, one is yielding an alkaline dilute calcium hydroxide solution, which also fortifies their food with an excellent source of calcium. When maize tortillas are cooked with lime treatment, however, the overall nutrient content of the corn decreases, even though the lime enhances the nutritional quality of the corn. This technique enhances the quality of proteins within corn for digestion. For instance, the ratio of isoleucine to leucine (1.8 times), as well as the amount of tryptophan, niacin, and lysine (2.8 times) are all significantly increased to be capable of digestion (Katz et al., 1974).

In one study, Katz et al. (1974) hypothesized that all societies that depend on corn as a staple crop adopt these alkali processing techniques when cooking maize, or they are at risk for developing malnutrition and pellagra. After analyzing the extent in which maize is cultivated and consumed, and if it was prepared using an alkali technique, Katz et al. (1974) found that nineteen out of fifty-one societies cultivated and consumed high amounts of maize, and applied alkali to process it. Thirty out of fifty-one societies relied less on cultivating and consuming maize, and thus did not use alkali for processing. These results reveal that those who subsist primarily on maize rely heavily on alkali processing techniques, and those populations that do not depend on maize, have a
supplementary source of protein (Katz et al., 1974). In summary, one can conclude that
the adoption of the cultural behavior of alkali processing techniques by Mesoamerican
societies has protected them against acquiring pellagra. Since the Europeans did not
embrace these alkali processing techniques with the integration of maize from the
Americas, pellagra became endemic among those who relied on maize as a staple crop
(Brenton, 1998).

Additionally, Goldberger discovered that pellagra is not caused by an infectious
agent, but is rather a result from an unbalanced diet. Pellagra became increasingly
prevalent in the Dixie of the United States, primarily due to a reliance on corn as well. In
1915, Goldberger conducted an experiment to understand the etiology of pellagra at
Rankin Prison Farm in Jackson, Mississippi. This location for his experiments was ideal
since prisoners were not suffering from pellagra (Harkness, 1996). Today, such an
experiment would be considered unethical. Goldberger and the governor of Mississippi
granted pardons for prisoners in turn for participating in the experiment. Prisoners were
given a diet consisting only of white flour, corn meal, hominy grits, cornstarch, white
rice, cane sugar, cane syrup, sweet potatoes, pork fat, cabbage, collards, turnips, turnip
greens, and coffee, all of which lack milk, lean meat, eggs and legumes, the primary
source of niacin. At that time, Goldberger only selected twelve Caucasian men to
participate since he felt they would be less susceptible to the disease than African
Americans. Goldberger deduced that a monotonous diet of meat fat, meal, and molasses
was the source of pellagra outbreak in the southern United States. Eventually, all of the
participating prisoners had escaped the onset of fatal pellagra (Harkness, 1996).
Carpenter and Lewin (1985) suggest that the pellagra epidemic in the United States was not satisfactorily explained. Historical pellagragenic diets were reevaluated by incorporating modern tables of nutrient composition. The data come from the detailed reports from Goldberger, an instrumental leader in understanding pellagra in the southern United States from 1916 to 1930. Five diets had higher niacin equivalents than the Recommended Daily Allowance of 6.6 mg/1000 kcal, as well as significantly lower levels of riboflavin. The U.S. Public Health Service conducted a series of trials for pellagra-preventative values of different foods from 1920 to 1936. Fifty of four hundred female subjects developed pellagra with 7.2-10.6 mg niacin/1000 kcal, while on diets containing sixty percent less RDA for riboflavin. This study reveals that many symptoms such as certain types of recorded dermatitis among the tested women and Goldberger’s results from Millidgeville were due to a riboflavin deficiency and not to nicotinic acid deficiency. Thus, there were differential signs of ordinary pellagra (Carpenter and Lewin, 1985).

More recently, Park et al. (2000) examined the role of niacin fortification within the U.S. food supply in order to identify the contributing factors that led to the eventual elimination of pellagra within the U.S. Possible contributing factors include changes in factors that could affect niacin nutriture like personal income, vitamin supplements, and food availability, the treatment of disease such as the evolution of understanding pellagra etiology and its associated foods, and the nutritional health status that would make people more susceptible to the disease (Park et al., 2000). Park et al. (2000) analyzed the recorded deaths (mortality) for pellagra death cases at the time of important federal regulations development that pertain to the fortification of cereal-grain products. Figure
Figure 1 shows the amount of pellagra deaths in the United States from 1929 to 1955, as well as the age-adjusted death rates per 100,000 people. The results from Figure 1 indicate that a substantial decrease in pellagra deaths occurred after the inception of the voluntary bread enrichment program in 1938 (Park et al., 2000).

Figure 1: Pellagra Deaths within the United States from 1925-1955 (Park et al., 2000:728)

Figure 2 also clearly portrays the number of pellagra deaths in the United States in the year 1930. From the map, one can conclude that most pellagra deaths occurred within the deep south, such as Alabama, Mississippi, Georgia, Florida, Louisiana, Tennessee, and South Carolina. However, Figure 2 illustrates that pellagra was not just isolated to
the south, but it was also prevalent in the southwest and northeast as well. This too shows that reliance of corn was not entirely confined to the southern region of the United States (Marks, 2003).

Moreover, Table 1 exhibits age adjusted pellagra death rates in the United States, as well as female to male ratio death rates for several years. Also, the results from Table 1 reveal that age adjusted rates were considerably higher for females than for males, and non-whites than for whites. In general, all of these results convey that food fortification designed to restore nutrients lost through grain milling played an important role in preventing pellagra during the 1930s and 1940s when food availability and food variety were considerably less than present day (Park et al., 2000).

Figure 2: Pellagra Mortality in 1930 (Marks, 2003:39)
Table 1: Age Adjusted Pellagra Death Rates in the United States and Female to Male Ratio for Death Rates Selected Years (Park et al., 2000:732)

On another note, Brenton (2000) analyzed morbidity and mortality rates of pellagra in relation to sex and gender from U.S. mortality statistics from 1900-1950, and found that women are twice as more likely to die from pellagra than men. This high pattern of female morbidity is due to a biocultural synergism of unequal access to nutrient dense foods, and estrogen’s inhibitory effect of converting tryptophan to niacin. However, lactation and pregnancy enhances the biochemical pathway of tryptophan to niacin conversion to take place, granted that the mother’s diet is sufficient in both nutrients (Brenton, 2000). For example, in Malawi during 1990, a pellagra outbreak of roughly 18,276 cases occurred (Brenton 1998). Here, pregnant and lactating Mozambican women had lower rates of pellagra than non-pregnant women (Brenton,
In addition, Brenton (2000) examined differential gender-based food consumption patterns in respect to pellagra. Within the first half of the twentieth century in the southern United States, men were primary wage earners and had greater access to buying foods outside of the home, while women earned considerably less income to be able to do this. Likewise, women would give protein quality foods to their children before themselves, eat their meals after everyone in the household had already eaten, and uphold cultural meals consisting of maize (grits), molasses, and fat-back pork (Brenton, 2000). Moreover, estrogen’s role in women from menarche to menopause in relation to pellagra was also reviewed. According to Brenton (2000), females between the ages of twenty and forty are at highest risk for developing pellagra, as seen with the age-dependent roles of estrogen. This shows that estrogen’s inhibitory effect of converting tryptophan to niacin is likely to make women more sensitive to acquiring pellagra (Brenton, 2000).

Discussion

In conclusion, pellagra can best be understood by implementing a biocultural model. By applying an alkali processing technique to maize, Mesoamerican societies have been protected against developing pellagra. However, Europeans most likely developed pellagra because they failed to adopt these alkali processing techniques. Furthermore, pellagra has been shown to be the result of an unbalanced diet, particularly in the southern United States where corn was also a staple variety crop. After 1938, pellagra deaths subsided in the United States primarily due to food fortification designed to restore nutrients lost through grain milling. Lastly, women are more likely to suffer and die from pellagra than men because of unequal access to nutrient dense foods, and estrogen’s inhibitory effect of converting tryptophan to niacin. This was not true in
pregnant and lactating Mozambican women, but was the case for women in the United States pre-Second World War. Thus, all of the aforementioned biocultural explanations for pellagra in European, American, and African populations reveal that pellagra has significant social implications. Great strides have been made in the last century in understanding a disease that was thought to be solely the result of a biological factor. Instead, a better emphasis has been placed on one’s cultural, social, and environmental attributes in order to fully understand why pellagra affects certain populations more than others.
References Cited


