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Weight Change and Hyponatremia as Predictors of Polydipsia Among Persons with Schizophrenia

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Abstract

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by

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MSC, Trinity College Dublin, 2010

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Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

Polydipsia, or compulsive drinking, is strongly associated with chronic schizophrenia. Most inpatients with chronic severe mental disorders who have polydipsia are diagnosed as having chronic schizophrenia. Despite the serious health complications of coexisting polydipsia in this population, its current method of detection is flawed. The purpose of this quantitative study was to accurately identify comorbid polydipsia in schizophrenia using periodic weight change and hyponatremia. Wilson's complexity theory provided the theoretical framework for the investigation, which featured a cross-sectional design. Data were gathered for 1,007 patients with chronic schizophrenia and its spectrum of a psychiatric rehabilitation hospital in Canada. Data from patients' charts or electronic records were analyzed mostly using logistic regression analysis; the aim was to explain the relationship between weight change and hyponatremia and polydipsia. The dependent variable was polydipsia, and the primary independent variables were weight change and hyponatremia. The covariates were age, age of onset, ethnicity, gender, duration of illness, length of hospital stay, and comorbidities. The findings of this study indicate that weight change and hyponatremia accurately detected excessive water intoxication or polydipsia, especially when it coexisted with schizophrenia. This knowledge is helpful because the other ways of screening for polydipsia, such as urine specific gravity and the Polydipsia Screening Tool, are prone to significant biases and cumbersome. By using weight change and hyponatremia instead, health care workers may be able to detect polydipsia earlier, which may promote patients' access to health care and overall quality of life.

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Dedication

This research is dedicated to my parents and all the vulnerable, particularly those living with severe mental disorders and addictions. My parents, especially my mother, Mrs. Blessing Nwachukwu, sacrificed their resources and prayers to push and encourage me to attain the greatest height and to empower me for the future. I would not be where I am today without my parents and the examples of hard work and faith laid before me to emulate. You believed in me and trusted that I was worthy of your sacrifice; hence I carry in me the resilience and faith instilled by your example. The empathy and compassion I have for persons living with mental disorders drove me to pursue my research in disability to the highest echelon, so I can meaningfully and significantly contribute to evoking positive social change.

Acknowledgments

I want to render my utmost appreciation to the Almighty God for enabling me to achieve this milestone. I acknowledge the strength and vigor I obtained from God in prayers, at crisis times during this study, when it almost seemed impossible to complete it. I must not also fail to mention the unique assistance from my research committee members, particularly from my chair, Professor James Rohrer.

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Chapter 1: Introduction to the Study

The majority of chronically ill psychiatric patients with extended or indefinite hospitalizations in psychiatric rehabilitation units are diagnosed with schizophrenia (Poirier et al., 2010). Schizophrenia affects about 1% of the world's population (World Health Organization, 2020). The disabilities caused by schizophrenia annually impact the world's global economy and significantly increase morbidity and mortality rates (Kirino et al., 2019). Polydipsia, or compulsive water drinking, complicates the diagnosis of schizophrenia, as well as worsens the prognosis (Rizvi et al., 2019). Up to 20% of people with chronic schizophrenia have comorbid polydipsia (Hawken et al., 2009). Polydipsia could be a symptom in other medical conditions like diabetes mellitus or coexist as a diagnosis with serious persistent mental illness, like schizophrenia (Torres et al., 2009).

The etiology of polydipsia is largely unknown, but some genetic and epigenetic biomarkers have been implicated (Yamada et al., 2014). The catechol-O-methyltransferase (COMT) with valine (108)/158 methionine functional polymorphism are biomarkers that have most consistently been associated with chronic schizophrenia with comorbid polydipsia (Yamada et al., 2014). However, the genetic etiology of mental disorders, particularly schizophrenia, is complicated and is best described as polygenetic; hence screening or detection of polydipsia by biomarkers is not considered reliable (Hawken & Beninger, 2014). The use of urine specific gravity (USG) or Polydipsia Screening Tool to identify polydipsia is prone to significant information bias and not accurate. In this study, I explored whether weight change and hyponatremia best detect excessive water intake and predict polydipsia coexisting with schizophrenia.

Problem Statement

Polydipsia, which is also referred to as compulsive water drinking or water intoxication, is defined as an abnormally excessive intake of oral fluid (Yamada et al., 2014). It is a severe condition reportedly found in over 20% of inpatients with chronic psychiatric disorders (Yamada et al., 2014). Among psychiatric inpatients found to have polydipsia, 80% have been diagnosed with schizophrenia, making it most closely linked with schizophrenia (Chu et al., 2017)**.** The physical comorbidities associated with schizophrenia and other chronic mental illnesses are often the causes of increased morbidities and mortalities (Krupchanka et al., 2018). The morbidities and mortalities caused by polydipsia in schizophrenia are enormous and have continued to increase (Aguiar et al., 2015). One of the challenges is that the particular cause of primary polydipsia in schizophrenia is unknown (Hawken & Beninger, 2014). Another challenge is that the current method of detecting primary polydipsia in schizophrenia is flawed and there is no newly revised detection method identified, despite its rampancy and fatality (Chu et al., 2017).

Polydipsia is an independent disease and can be prevalent among patients with physical illnesses such as diabetes mellitus (Yamada et al., 2014). When found in patients with physical illnesses, it is usually a symptom and often regarded as medically induced, as it is secondary in origin (Hawken & Beninger, 2014). However, when found in patients with psychiatric disorders, especially in schizophrenia, the cause is unknown and difficult to manage (Aguiar et al., 2015). Studies have shown the presence of genetic and epigenetic biomarkers such as COMT with a functional polymorphism of valine

(108)/158 methionine in patients with polydipsia (Yamada et al., 2014). Among patients with psychiatric disorders, the COMT genetic marker is most commonly found in patients with schizophrenia (Gratten et al., 2014; Yamada et al., 2014). Researchers have concluded that finding the COMT genetic marker in primary polydipsia is probably why it is most commonly linked or susceptible to schizophrenia (Hawken & Beninger, 2014; Uher, 2013). Irrespective of type and cause, polydipsia complicates preexisting conditions and may lead to electrolyte imbalance in the body, with emphasis on hyponatremia resulting from over dilution (Chu et al., 2017). Polydipsia or water intoxication may result in congestive heart failure, renal failure, dilation of the bladder, incontinence, enuresis, and hydronephrosis (Yamada et al., 2014). Further neurobiological symptoms from hyponatremia may also lead to delirium, seizures, ataxia, nausea, vomiting, and even death (Yamada et al., 2014).

Polydipsia is a complex situation among those diagnosed with schizophrenia, with ever increasing incidence and prevalence (Long et al., 2018). Therefore, the problem is the lack of appropriate identification or detection method of polydipsia with schizophrenia. Identification is crucial, as strict and unchecked restriction of patients from accessing adequate daily amount of water may conversely result in dehydration with its complications (Yamada et al., 2014). Addressing the complexity of polydipsia and reducing, if not eliminating, the incidence and prevalence of it, especially when comorbid in schizophrenia, lies in accurate and reliable predictors or risk factors that are important to detection (Chu et al., 2017).

Purpose of the Study

The purpose of this study was to explore how weight change and hyponatremia could better accurately and reliably detect coexisting polydipsia in individuals with schizophrenia in psychiatric inpatient units. Study findings may help health care workers to improve the identification or detection of a comorbid polydipsia in schizophrenia. To address the study purpose, I applied a quantitative design. I assessed periodic weight gain and other laboratory measures in patients diagnosed with schizophrenia, with suspected comorbid polydipsia, in an inpatient psychiatric unit.

Research Questions and Hypotheses

RQ1-Quantitative: Is polydipsia associated with weight change when controlling for age, gender, age of onset, duration of illness, and length of hospital stay?

$H_0$1: Polydipsia is not associated with weight change when controlling for age, gender, age of onset, duration of illness, and length of stay.

H_a1: Polydipsia is associated with weight change when controlling for age, gender, age of onset, duration of illness, and length of stay.

RQ2-Quantitative: Is polydipsia associated with hyponatremia, when controlling for age, gender, age of onset, duration of illness, and length of hospital stay?

$H_0$2: Polydipsia is not associated with hyponatremia, when controlling for age, gender, age of onset, duration of illness, and length of hospital stay.

H_a2: Polydipsia is associated with hyponatremia, when controlling for age, gender, age of onset, duration of illness, and length of hospital stay.

RQ3-Quantitative: Is polydipsia associated with weight change and hyponatremia, when controlling for age, gender, age of onset, duration of illness, and length of hospital stay?

$H_0$3: Polydipsia is not associated with weight change and hyponatremia, when controlling for age, gender, age of onset, duration of illness, and length of hospital stay.

*H*a3: Polydipsia is associated with weight change and hyponatremia, when controlling for age, gender, age of onset, duration of illness, and length of hospital stay.

Theoretical Framework

The theoretical framework that grounded this research was Wilson's complexity theory, which emerged in the late 20th century. It is a public health theory that states that human beings have complex biological and social systems that are compromised when illness occurs, causing unpredictable patterns of behavior that challenge health care providers and require a wide array of interventions (Dunn & Riley-Doucet, 2017). The complexity theory is interdisciplinary in nature, and it addresses the gap created over the years by the lack of theoretical frameworks to explain complex health behaviors and interventions encountered by public health researchers as well as clinicians (Caffrey et al., 2016). The complexity theory is pedagogical and versatile, and can be applied in quantitative, qualitative, or mixed-methods studies (Thompson & Fazio, 2016). It has been successfully used to explain chronic and complex diseases like diabetes, which has led to interventions around quantitative measures of blood sugar levels for a more

accurate screening (Cooper et al., 2014). Polydipsia is a chronic and complex disease, which predominantly coexists in schizophrenia, diabetes, and other chronic mental and physical health conditions. The complexity theory was best suited to explore the complex interdisciplinary nature of primary polydipsia comorbidity in schizophrenia. Using quantitative measures of periodic weight changes, I sought to provide a more accurate and reliable assessment of primary polydipsia in schizophrenia.

Nature of the Study

The nature of this study was quantitative. I concluded that a quantitative approach was the best way to understand the relationship among weight measures, blood sodium levels, and polydipsia and address the problem of proper detection of polydipsia. This approach was consistent with that of Chu et al. (2017), who used before and after weight measurements of suspected cases of polydipsia in a psychiatric inpatient unit to identify water intoxication. To adequately identify and resolve the relationship between the study variables, I examined before and after weight measurements and blood sodium levels taken over a 5-year period in a psychiatric inpatient unit of suspected and confirmed cases of associated polydipsia.

Definitions

Comorbidities: Mental and/or nonmental disorders that coexist with a main or primary diagnosis (Torres et al., 2009). Polydipsia is a comorbid illness when it coexists with an already existing illness or disorder, like schizophrenia or diabetes mellitus. Comorbidities nearly always worsen the prognosis of a primary disorder and can also

cause more medical complications (Risvi et al., 2019). For this study, the comorbidity of interest was polydipsia, and the main or primary diagnosis was schizophrenia.

Genetic polymorphism: Molecular biology appears to have a significant role in the interplay of genes and genomics of polydipsia, lending some vulnerability from genome-wide association studies to chronic schizophrenics who become polydipsic (Matsumoto et al., 2005; Yamada et al., 2014). The study of heredity, which is called genetics, and genomics, which is defined as the study of genes and their functions, have been useful in further discoveries of genetic markers between polydipsia and schizophrenia at the molecular level (World Health Organization, 2016). The COMT Valine 108/158 + Met genotype has been consistently found in polydipsia among persons living with chronic schizophrenia (Yamada et al., 2014; Kirino et al., 2019). This is worthy of further exploration. Using genetic markers might become quite helpful in future screening for polydipsia.

Polydipsia: The consumption of excessive amounts of fluid by an individual, which can be compulsive and inexplicable and which can expose them to potentially fatal hyponatremia (Kirino et al., 2019; Reynolds et al., 2004). When excessive water intake or water intoxication becomes compulsive and has happened over time, it becomes a significant problem and may then be diagnosed substantively as polydipsia (Kirino et al., 2019). The condition has been reported in other chronic medical illnesses such as diabetes mellitus, diabetes insipidus, and brain tumors and injuries, but it is commonly seen in schizophrenia particularly when severe and chronic (Greendyke et al., 1998). Twenty percent of hospitalized persons with severe chronic schizophrenia in a psychiatric

unit has comorbid polydipsia (Kirino et al., 2019). It is quite prevalent among chronic schizophrenics. The presence of polydipsia in schizophrenia complicates the treatment and complications of schizophrenia, as well as worsens its prognosis (Kirino et al., 2019).

Mitigating the impact of polydipsia on individuals with schizophrenia with comorbid polydipsia is contingent on accurate detection and monitoring, according to Reynolds et al. (2004). This is essential as it can be life threatening for patients, who might develop seizures from hyponatremia or acquire systemic infection from intake of contaminated fluid or become more psychotic (Greendyke et al., 1998). Other symptoms of polydipsia are neurologic problems (blurring of vision, headache, muscle cramps, tremors, weakness, confusion, restlessness, delirium, lethargy, seizures, coma and even death); cognitive and behavioral problems; urinary tract disease (renal failure, hydronephrosis, incontinence, gastrointestinal symptoms, metabolic problems (osteopenia, hypocalcemia); and congestive heart failure (Greedyke et al., 1998).

No particular factor or etiologies have been known to lead to polydipsia; hence its cause is considered unknown (Yamada et al., 2014). However, polydipsia is seen in 20% of persons living with chronic schizophrenia (Parikh et al., 2016). The COMT Valine 108/158+ Met genotype is the only consistent genetic marker found in polydipsia coexisting with chronic schizophrenia (Yamada et al., 2014).

Polydipsia Screening Tool: A screening tool that is used to detect polydipsia in patients. Polydipsia is detected in urine by measuring USG, in blood by measuring serum sodium blood level, or in the body by measuring changes in body weight (Reynolds et al., 2004). Screening helps to accurately detect polydipsia in schizophrenia (Kirino et al.,

2019). Improvement in existing detection techniques like USG and the 17-item Polydipsia Screening Tool will improve the validity and reliability of predicting polydipsia (Reynolds et al., 2004). In turn, accurate and early identification of polydipsia in patients with schizophrenia will help reduce the morbidity and mortality it causes (Kirino et al., 2019). The 17-item Polydipsia Screening Tool is one that utilizes outcome measures from a set of 17 criteria or parameters related to polydipsia, which are scored on levels of severity (Reynolds et al., 2004).

The population being screened for polydipsia are diagnosed with chronic schizophrenia, are often cognitively challenged, and are vulnerable; hence their ability to follow rules and instructions without supervision is severely compromised (Kirino et al., 2019). Having schizophrenia for years significantly impacts one's cognition, especially memory, attention, concentration, and executive functioning, among others (Poirier et al., 2010). Screening with USG can be cumbersome for persons living with schizophrenia with comorbid polydipsia. Also, urine samples can be intentionally manipulated to avoid the detection of polydipsia. For instance, urine can be diluted, mixed with other fluids, or intentionally obtained from someone else (Poirier et al., 2010). The responses to the 17-item Polydipsia Screening Tool from this patient population may not be accurate or reliable; also, using the tool is cumbersome (Reynolds et al., 2004). In contrast, screening with weight change and hyponatremia cannot be manipulated by patients, except by the professional reading the wight or blood investigation report (Parikh et al., 2016).

Schizophrenia: A serious mental disorder defined by two or more of the following: delusion, hallucination, disorganized speech, grossly disorganized or catatonic

behavior, and negative symptoms called Criteria A symptoms; each present for a significant portion of time during a month period (or less if successfully treated), and at least one of these must be delusion, hallucination or disorganized speech (American Psychiatric Association, 2013). To rule out other possible differential diagnosis, it is important to consider other Criteria B to F parameters, which range from 6 months duration, significant functional decline, and the exclusion of substance use disorders and other psychiatric disorders (American Psychiatric Association, 2013). For correctness of classification, the criteria for defining schizophrenia are further ranked into specifiers according to their frequencies, duration, and acuity such as first episode, multiple episodes, and severity (American Psychiatric Association, 2013). Persons living with schizophrenia are usually out of touch with reality and may have associated significant cognitive problems depending on the duration and refractoriness of their illness (Yamada et al., 2014). Schizophrenia sometimes has other psychiatric disorders, physical health problems, or substance use disorders coexisting with it, which often worsens its prognosis (Yamada et al., 2014).

Assumptions

I anticipated the possibility of missing data. To address this concern, I applied the case wise or list wise data deletion method in the data manager. The variables obtained were provided by the participants. I pulled data on participants' history of polydipsia and comorbidities, when appropriate, from participants' charts or electronic records. Finally, continuity of care documentation was recoverable.

Scope and Delimitations

I obtained the data for this research from charts of current inpatients (for the last year at least) and electronic health records (for the last 5 years), from a psychiatric inpatient hospital located in a Canadian province. These records only included polydipsia with comorbid schizophrenia. It did not matter whether there were other psychiatric comorbidities. The use of retrospective data from 5 years of electronic and current inpatient records was one of the delimitations of this study. Further, this research might also be delimited by the inclusion of only certain variables in the data set. There was no control group available for comparison or interpolations.

Limitations

It is important to recognize some of the limitations that may occur. The data set I used had some missing valuable variables due to the dependence on secondary data analysis. The conclusions or findings that I reached from this study was affected by missing data, as it is difficult for me to ensure there was no missing data from trouble in modifying the primary data set. The varied recall abilities of the patients might also have resulted in information bias and might impact the outcome of this study negatively.

Significance

In conducting this study, I sought to provide a more accurate and reliable way of assessing or measuring comorbid water intoxication or polydipsia in those diagnosed with schizophrenia. I wanted to support and enhance the abilities of clinicians and other health care workers to properly identify and manage polydipsia (Hawken & Beninger, 2014). Public health scholars and other researchers in the field may also be able to use the

knowledge from the study on measuring weight discrepancy in suspected cases of polydipsia in schizophrenia to develop educational programs (McDonald & Raymaker, 2013). The study is pertinent, as the prevalence of water intoxication is rising in society, causing increased morbidities and mortalities (Yamada et al., 2014).

Proper identification and detection of comorbid polydipsia in schizophrenia is needed as an important step to addressing the problem (Aguiar et al., 2015). The findings in this study may provide guidance that clinicians can use to help reduce the prevalence of and adequately manage comorbid polydipsia in patients with schizophrenia, which would represent positive social change. Patients with other psychiatric and nonpsychiatric conditions associated with polydipsia might also benefit from the result of this study.

Potential for Positive Change

Mental disorders alone cause significant health and economic impacts; these are even worse for those living with schizophrenia, who make up to 1% of the population (Yamada et al., 2014). Any comorbidities to a preexisting mental or physical illness tend to worsen the features and prognosis of the primary diagnosis (Kirino et al., 2019). Polydipsia is seen in 20% of those suffering from chronic schizophrenia and is a major cause of increased morbidity and mortality in this population (Hawken et al., 2009).

Mental disorders constitute a significant global disease burden, and their impact can cost over $16 million between 2011 and 2030 estimably (World Health Organization, 2016). It is quite challenging to accurately and reliably screen for polydipsia in vulnerable populations, especially persons living with schizophrenia (Yamada et al., 2014). Having a simple but valid and reliable method of screening for polydipsia can

create a routine systematic approach. This may enhance the detection of polydipsia and improve the standard of care offered by psychiatrists and primary care general practitioners, reduce the negative health impact on those with the condition, and may improve the economy.

The outcomes of this study might bridge the knowledge gap in predicting polydipsia in chronic schizophrenia and improve its screening efficiency. Study findings may also be used to enhance policy guidelines and better decision-making, as well as implementation. Compliance, follow-up, and sustainability with guidelines are contingent on enforcement after implementation (Kirino et al., 2019). Furthermore, knowledge acquired from the results of this study could enable primary care and mental health workers to develop better health programs. This could also promote empowerment of health care workers, especially mental and primary health care workers, to take ownership and improve quality of life by offering early detection of polydipsia and easier access to health care.

Summary

In Chapter 1, I provided an overview of the study and the need for accurate, reliable, and routine screening for polydipsia in patients schizophrenia. Further, I discussed the purpose and nature of the study, as well as presented the RQs and hypotheses. The assumptions, limitations, and scope and delimitations were also provided. Finally, I described the social change impact of the study. In Chapter 2, I will review key literature related to the study topic.

Chapter 2: Literature Review

Literature Search Strategy

To find peer-reviewed journal articles and other literature for the study, I searched the following Walden University Library databases: ProQuest Central, Dissertation and Theses @ Walden University, ProQuest Dissertation & Theses Global, SAGE Research Methods Online, Cochrane Database of Systematic Reviews, SAGE Stats, MEDLINE with Full Text, CINAHL Plus with Full Text, SAGE Knowledge, Science Direct, Science Journals, PubMed, and Walden Library Books. Other useful sources were the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.) and the *International Classification of Diseases* (11th rev.); the websites of the World Health Organization, Centers for Disease Control and Prevention, American Psychiatric Association, Canadian Psychiatric Association, and Health Canada; and Google Scholar. In my searches, I used the following key words: *polydipsia*, *hyponatremia*, *schizophrenia*, *weight*, *weight gain*, *weight change*, *water intoxication*, *comorbidities*, *plasma electrolytes*, *urine specific gravity*, *Polydipsia Screening Tool (17-item)*, *gender*, *age*, *age of onset*, *hospitalization*, *length of hospitalization*, *patient population*, *ethnicity or race*, *education*, *marital status*, *genetic polymorphism*, *genome-wide association studies*, *antipsychotics*, *Brief Psychiatric Rating Scale, Positive and Negative Symptoms Scale* (*PANSS*), and *global assessment of functioning* (*GAF*). In conducting a wide open-ended literature search, I made every effort to limit the scope to primary peer-reviewed publications published within the last 5 years, except for a few older appropriate and similar studies.

Literature Review Related to Key Variables and/or Concepts

Relationship Between Polydipsia and Chronic Schizophrenia

Length of hospitalization among those living with schizophrenia is synonymous with severity of the illness (Hawken et al., 2009). Onset of illness or duration of illness is not necessarily synonymous with length of hospitalization in schizophrenia (Hawken et al., 2009). Polydipsia is mainly found among inpatients with severe schizophrenia who have been consistently hospitalized for at least 5 years in one of the episodes, in their entire history from the onset (de Leon et al., 1996). It is important to consider assessing for polydipsia in patients with severe schizophrenia who have been hospitalized for 5 years or more in a particular episode frequency of hospitalization. In one study, polydipsia was found in about 5% of patients living with severe major depressive disorder and severe bipolar and related disorder who had been hospitalized for 5 years or longer (de Leon et al., 1996). This makes length of hospitalization an essential independent variable. Population, which seems to connect severity to polydipsia, not only in severe schizophrenia, also needs to be included in studies.

de Leon et al. (2002) performed a replication study on 588 chronic inpatients diagnosed with schizophrenia in the United States to explore the relationship between polydipsia and chronic schizophrenia in the psychiatric hospital setting. Interesting, the association between polydipsia and chronic schizophrenia was found to be consistent and independent from the conceptual meaning of polydipsia by staff and when perceived from the biological method, or a combination of both.

Duration of Illness

Chronicity has been significantly linked to the onset of polydipsia in schizophrenia (Greendyke et al., 1998). de Leon et al. (2002) found that 20% of chronic schizophrenics were diagnosed with polydipsia. They were inpatients rather than outpatients, who were hospitalized with severe degrees of mostly schizophrenia and/or other serious mental illnesses (de Leon et al., 2002). The severity of schizophrenia seems to play a significant role in the onset of polydipsia and hospitalization (Greendyke et al., 1998). Nearly all those who have severe schizophrena and polydipsia are inpatients with no less than 10 years history of the schizophrenia (de Leon et al., 2002). The duration of illness in schizophrenia is a function of its severity, which also determines a chronic course (Greendyke et al., 1998).

Frequency of Hospitalization

The more an individual suffering from schizophrenia relapses and is hospitalzed, the less likely they stay in remission between episodes and the greater the severity of their condition (Shutty & Song, 1997). Nearly all patients with severe schizophrenia with comorbid polydipsia have had five or more inpatient admissions to a psychiatric unit in their lifetime (de Leon et al., 1996). There is a relationship between primary polydipsia and the number of psychiatric hospitalizations in chronic or severe schizophrenia, which is not however causal.

Age of Onset

Severe schizophrenia with comorbid primary polydipsia is rarely seen in early psychosis or below the age of 25 (Torres et al., 2009). Early onset schizophrenia tends to

be more genetically related and run a chronic cause, except when it is substance–induced (Poirier et al., 2010). However, over 80% of polydipsia in schizophrenia are above 40 years of age (Poirier et al., 2010). In the view of experts, the comorbid polydipsia in schizophrenia cases found in adults, including older adults, represents poorly prognosticated early onset cases prone to persistent and resistant courses (Torres et al., 2009).

Genetic Markers Connecting Polydipsia and Chronic Schizophrenia

Yamada et al. (2014) in a case-control study, demonstrated the effect of the COMT Val 108/158Met genotype on the risk for polydipsia in persons with chronic schizophrenia. This was a large study that involved inpatients from 15 psychiatric hospitals to investigate the relationships between polydipsia, hyponatremia, and COMT/Val genotype variables. Yamada et al. (2014) found that the COMT Val 108/158 Met genotype may confer susceptibility to polydipsia in schizophrenia. The association sustained after controlling for confounders such as age, age of onset, antipsychotic dose, and smoking status.

Matsumoto et al. (2005) explored the association between three functional polymorphisms of the dopamine D2 receptor gene and polydipsia in schizophrenia using case-control study as well. Sixty-four inpatients with chronic schizophrenia and polydipsia, in addition to 91 inpatients with chronic schizophrenia without polydipsia who served as controls, were recruited from psychiatric hospitals to investigate this relationship. Matsumoto et al. (2005) found that the polymorphisms in dopamine D2 receptor gene may confer susceptibility to polydipsia in schizophrenia.

The dysfunction in the central nicotinic receptors (nAChRs) represents a common substrate for various symptoms of schizophrenia and comorbid nicotine dependence, particularly with associated polydipsia, according to Parikh et al. (2016). Parikh et al. (2016) deduced this in a study that focused on nAChRs dysfunction as a common substrate for schizophrenia and comorbid nicotic addiction, associated with polydipsia, to look at current trends and perspective. In this systematic review, the authors evaluated a total of 276 articles from Medline, Google Scholar, and Web of Science using key words such as *smoking*, *schizophrenia*, *nicotine*, *nAChRs*, *cognition*, *negative symptoms*, *positive symptoms*, *genetics*, *addiction*, *neurobiology*, and *antipsychotics*.

Public Health Impact of Polydipsia in Schizophrenia

In a retrospective cohort study, Hawken et al. (2009) studied the mortality in patients with chronic schizophrenia with comorbid primary polydipsia over a 20-year period. Chart reviews of 172 psychiatric inpatients on long stay wards in Ontario, Canada, were carried out on those patients who had been admitted for at least a year and who had been diagnosed with polydipsia associated with polydipsia. They found a significant increase in mortality seen when polydipsia is associated with schizophrenia, in comparison to that in patients with schizophrenia without water intoxication.

de Leon et al. (1996) carried out a cross-sectional study on polydipsia and water intoxication to see how it impacts length of hospitalization among persons living with schizophrenia. The authors conducted their study in inpatient units in a psychiatric hospital. The cases examined where those of 360 chronically mentally ill patients with schizophrenia and other serious mental disorders. Interestingly, there was significantly

more extended hospitalizations in all patients with history of water intoxication associated with schizophrenia. This means increased morbidity and utilization of hospital beds in this population, which can be quite costly as well.

Torres et al. (2009) argued that there is more significant neuropsychological impairment in patients with schizophrenia who show evidence of hyponatremia and polydipsia. The authors demonstrated this in a cross-sectional study involving psychiatric in- and outpatient facilities throughout the Chicago area and Psychiatric Clinical Research Center at the University of Illinois at Chicago. All of these patients had chronic schizophrenia, seven had hyponatremia, and 10 had polydipsia while nine neither had polydipsia nor hyponatremia. It was shown that in those patients with schizophrenia with associated polydipsia and/or hyponatremia, there were significant cognitive deficits in various domains, compared with patients without associated polydipsia problem.

In a cohort study, Poirer et al. (2010) studied 114 subjects diagnosed with schizophrenia who were psychiatric inpatients and outpatients, under the age of 50, and with 5 or more years' history of psychiatric follow-up. The researchers sought to explore the impact of polydipsia in this population). They found that more severe psychotic symptoms, earlier onset, poorer current adjustment, and more frequent prior alcohol use disorder were associated with polydipsia or water intoxication in schizophrenia.

Shutty and Song (1997) conducted research of the behavioral analysis of drinking behaviors in polydipsic patients with chronic schizophrenia. The researchers conducted a case-control study of 15 White male patients diagnosed with chronic schizophrenia in a 450-bed state psychiatric facility; of the 15 patients, nine had polydipsia, and six were

controls. The amount drunk per bout for polydipsia patients was nearly three fourths greater than in controls. The frequency and concentration of drinking bouts were the most consistent abnormality among polydipsia patients. However, amount drunk per bout and rate of drinking were similar across groups.

Pharmacologic Role in Polydipsia in Schizophrenia

Greendyke et al. (1998) conducted a randomized double-blind, placebo-controlled study to investigate the therapeutic values of clonidine and enalapril on polydipsia in chronic psychiatric patients. Fourteen chronically psychotic and institutionalized patients who suffered from psychogenic polydipsia were recruited from 244 psychiatric inpatients to partake in this study. In 60% of subjects, there was a particular improvement in tests that reflect fluid consumption found with either or both medications. However, there was no significant improvement in other behaviors.

Kirino et al. (2019) conducted a systematic review of clinical studies and case reports to establish the relationship between polydipsia and antipsychotics. They searched through MEDLINE, Embase and PsychINFO via Ovid with keywords such as drink or water intoxication, water or fluid concentration, and antipsychotic. One of the findings was that antipsychotics with high affinity to dopamine D2 receptors maybe associated with an increased risk of polydipsia, while clozapine maybe effective for treating polydipsia. Another finding was that causal relationship between polydipsia and antipsychotics remains unclear because of the paucity of high-quality studies.

Rizvi et al. (2019) explored the role of naltrexone in improving compulsive drinking in psychogenic polydipsia. They extensively reviewed journals and articles of

internal medicine, pain management and psychiatry using the following keywords: naltrexone, psychogenic polydipsia, schizophrenia, compulsive drinking and opioid receptor. It was found that opioid receptor correlates with compulsive water ingestion in animals, which then suggests that naltrexone can play an important role in treating psychogenic polydipsia in chronic psychiatric patients.

Screening Indicators for Polydipsia

Weight

Weight is the most obvious and easily assessable key determinant variable. Weight varies a lot from person to person, gender, and age (Reynolds et al., 2004). The current standard unit for weight measurement according to (World Health Organization, 2020) is in kilograms. Weight can be measured by different types of weight apparatus or weighing machine (World Health Organization, 2020). An individual's weight is not necessarily a reflection of only body fluids, but a combination of height, muscle mass, bones, other connective tissues, body organs, and gender (World Health Organization, 2020). Generally, an adult has a body mass index of between 18.5 to 24.9 (measured in kg/m squared), Health Canada (2016). It is not often easy or straightforward to measure weight, especially in individuals with severe chronic schizophrenia, due to noncompliance or mobility problems (Reynolds et al., 2004). It is part of the routine to measure weight periodically in inpatients, including psychiatric inpatients (Reynolds et al., 2004). The frequency of weight measurement differs from one inpatient to the other, depending on the need and focus of attention (Reynolds et al., 2004).

Significance of Weight Change. One of the most reliable quick screening bedside methods of detecting suspected excess water intake in schizophrenia with comorbid polydipsia, is weight measurement (Matsumoto et al., 2005). Weight change or gain, from multiple accurate weight measurements across the day in suspected water intoxication is useful in the detection of polydipsia (Matsumoto et al., 2005). The baseline weight in kilograms before excessive water intake, must have been obtained, as a mandatory requirement for accuracy of the screening (Reynolds et al., 2004). The difference in multiple weight measurements across the day, is obtained by subtracting subsequent random weight measures across the day, from the baseline weight measured on the ward before water intoxication (Reynolds et al., 2004).

Hyponatremia

Hyponatremia is defined by serum sodium levels falling below 135mmol/L (Reynolds et al., 2004). Sodium is a salt as an element, but more importantly, one of the plasma electrolytes that regulates the level of hydration via its influx into or exflux from the body cells (Reynolds et al., 2004). Optimum sodium level is essential for normal body functioning and must be within normal limits, which is between 135 and 145 mmol/L (World Health Organization, 2020) referred to as the "normal range." (World Health Organization, 2020). When the plasma sodium level is below 135 mmol/L, it is termed hyponatremia, and when it is above 145 mmol/L, it is termed hypernatremia (World Health Organization, 2020). Hyponatremia and hypernatremia can both have negative impacts on body cell functioning (Poirier et al., 2010). For the scope of this research, the focus is on hyponatremia. Hyponatremia is found in all individuals with

polydipsia (Poirier et al., 2010). Hyponatremia is a reliable indicator in the detection of excess water intake in chronic inpatients with schizophrenia and can only be screened by conducting blood investigations (Reynolds et al., 2004).

Electrolytes

Body electrolytes or body minerals are very vital in neurotransmission between nerves, depolarization, and repolarization to generate action potential, and also serve as part of the essential body minerals (Parikh et al., 2016). In addition to sodium, other body electrolytes are potassium, calcium, iron, zinc, magnesium, chloride, fluoride, sulfur, and copper (Parikh et al., 2016).). The activities and availability of sodium in the body, are impacted by other electrolytes, particularly calcium, potassium, and chloride (Parikh et al., 2016).

Significance of Screening Indicators

Excessive or compulsive water intake, leading to water intoxication or polydipsia, causes low sodium levels in the blood otherwise known as hyponatremia (Greendyke et al., 1998). Hyponatremia causes electrolyte imbalance, which can result in a cascade of abnormal events culminating in morbidity and mortality, and that is a public health issue (World Health Organization, 2020). Hyponatremia can be detected in the blood samples of those diagnosed with severe chronic schizophrenia with comorbid polydipsia (Torres et al., 2009). Since the screening of hyponatremia is done by blood investigation, it is therefore an accurate and a reliable method of detecting polydipsia in suspected individuals, as it cannot be falsified.

Screening Tools

Urine Specific Gravity Measurement

USG is currently used to screen for water intoxication or excessive water intake suspected in individuals with chronic severe schizophrenia with comorbid polydipsia in inpatient units (Shutty & Song, 1997). It is the ratio of the density of urine to that of water (Stuempfle & Drury, 2003). This type of screening has been the conventional method of detecting water intoxication for many decades and may not necessarily be accurate anymore (Shutty & Song, 1997). The accuracy and reliability of detecting excess water intake by USG, is prone to errors from urine sample impurities, manipulations by the individual providing the urine specimen, collection of samples into a wrong container, or inaccurate reading (Shutty & Song, 1997). The normal range of USG is usually from 1.002 to 1.030 (Stuempfle & Drury, 2003). Different levels of hydration are euhydration when USG is less or equal to 1.020 and hypohydration or dehydration when it is greater or equal to 1.020, which are often used to connote severity, Stuempfle and Drury (2003).

The 17-Item Polydipsia Screening Tool

Reynolds et al. (2004) tested the validity and reliability of the 17-item Polydipsia Screening Tool, using a cross-sectional study. This tool was applied to screen for polydipsia in a 92-bed nursing home, on 70 psychiatric residents diagnosed of chronic schizophrenia with other comorbid mental disorders and 5 staff nurses working at this facility. Variables such as age, gender, hyponatremia, USG, weight change, smoking, among other characteristic symptoms were items screened for and each scored on graded levels of severity. It was found that the interrater reliability was 0.84, the average test-

retest agreement was 92.4% with agreement ranging from 75% to 100%, and internal consistency of the tool was 0.79. Its sensitivity was 80% while its specificity was 68%. The authors also discovered that the validity of the Polydipsia Screening Tool was corroborated using medical record history of polydipsia, low specific gravity, and low sodium levels.

The 17-item Polydipsia Screening Tool attempts to screen inpatients with long history of schizophrenia with other comorbid mental disorders, including polydipsia (Reynolds, Schmid & Broome, 2004). Important variables such as hyponatremia, weight change, USG, among other items, used to obtain outcome scores, which are then measured for reliability, validity, sensitivity and specificity, Reynolds, Schmid and Broome (2004). This tool is not widely used, even though it is highly recommended by researchers.

Summary and Conclusions

All through the literature search there were five major significant themes; relationship between polydipsia and schizophrenia, standards for clinical screening for polydipsia, genetic markers connecting polydipsia and schizophrenia, the public health impact of polydipsia in schizophrenia, and the management of polydipsia in schizophrenia. The literature showed there was a significant association between polydipsia and schizophrenia, which made it necessary to explore. The current standard clinical screening for polydipsia involves identification of excess water intake or water intoxication using USG or Polydipsia Screening Tool. These could be prone to error of measurement bias, problem with reliability and validity, or being too cumbersome with

respect to polydipsia measuring tool. Weight change and hyponatremia are more reliable and valid indicators that can predict water intoxication according to this literature study.

Similar genetic markers and polymorphisms around dopamine receptors, have been consistently found among persons living with chronic schizophrenia with comorbid polydipsia. This is another promise of even more reliable method of predicting polydipsia in chronic schizophrenia by genetic analysis. The management of polydipsia is contingent on the reliability and accuracy of its detection. On the one hand, behavioral water restriction mode of management benefits from the methods of screening via USG, weight change, hyponatremia, and Polydipsia Screening Tool. On the other hand, pharmacological mode of management benefits from genetic markers and dopamine receptors polymorphism. These themes are further explained in detail by published articles and studies that laid the foundation and basis of this study (see Appendix).

Chapter 3: Research Method

Introduction

The purpose of this study was to explore how weight change and hyponatremia might accurately and reliably detect coexisting polydipsia in individuals with schizophrenia in psychiatric inpatient units. Clarifying this relationship could also help in accurately and reliably screening for excessive water intake or polydipsia in patients with other psychiatric and nonpsychiatric disorders. The focus of this research was on inpatients with chronic schizophrenia who are either currently on admission or not, going back 5 years in time. I analyzed cross-sectional data by using logistic regression guided by Wilson's Complexity theory of public health. Weight measures and sodium levels were independent variables I employed to explore this association. The dependent variable was polydipsia, as predicted. The covariates were centered on age, age of onset, gender, ethnicity, length of admission, duration of illness, and comorbidities since they were all diagnosed with schizophrenia.

In this chapter, I describe the research design and methodology in the context of variables, covariates, setting, sample size, RQs and hypotheses, and target population. I also discuss the data analysis plan, management of data, threats to data validity, and ethical considerations. In addition, I describe my evaluation of multiple modeled studies that had similar findings while controlling for covariates and my application of the Wilson complexity theory of public health.

Research Design and Rationale

In this research, I used quantitative methodology featuring a cross-sectional study design and logistic regression analysis. The logistic regression analysis was used to answer the RQs and examine the predictive relationship between the independent and dependent variables. Weight measures and blood sodium levels were independent variables; they were continuous numerical data. Conversely, polydipsia, which was the dependent variable, presented categorical or nominal data as responses, which were coded as either present or absent. The covariates were a mixture of numerical, categorical, and ordinal data. I completed the analysis of data by using SPSS software. The RQs and hypotheses were as follows:

RQ1-Quantitative: Is polydipsia associated with weight change when controlling for age, gender, age of onset, duration of illness, and length of hospital stay?

$H_0$1: Polydipsia is not associated with weight change when controlling for age, gender, age of onset, duration of illness, and length of stay.

H_a1: Polydipsia is associated with weight change when controlling for age, gender, age of onset, duration of illness, and length of stay.

RQ2-Quantitative: Is polydipsia associated with hyponatremia, when controlling for age, gender, age of onset, duration of illness, and length of hospital stay?

$H_0$2: Polydipsia is not associated with hyponatremia, when controlling for age, gender, age of onset, duration of illness, and length of hospital stay.

H_a2: Polydipsia is associated with hyponatremia, when controlling for age, gender, age of onset, duration of illness, and length of hospital stay.

RQ3-Quantitative: Is polydipsia associated with weight change and hyponatremia, when controlling for age, gender, age of onset, duration of illness, and length of hospital stay?

$H_0$3: Polydipsia is not associated with weight change and hyponatremia, when controlling for age, gender, age of onset, duration of illness, and length of hospital stay.

H_a3: Polydipsia is associated with weight change and hyponatremia, when controlling for age, gender, age of onset, duration of illness, and length of hospital stay.

Methodology

In this section, I describe the population of the study; setting and sampling procedure, including the power calculation to derive the sample size; instruments and materials; data analysis strategy; and threats to validity.

Population

The target population for this research was inpatients in rehabilitation psychiatric units with a long history of schizophrenia with possible polydipsia comorbidity. These patients were admitted to the study facility from other psychiatric centers due to the chronicity and resistance to treatment of their illness. All schizophrenia spectrum diagnoses, including those with affective symptoms such as schizoaffective disorder, were relevant if they included comorbid polydipsia.

Sampling and Sampling Procedures

I obtained historical information of patients with chronic schizophrenia and its spectrum from patients' charts or electronic records. These were inpatients in a psychiatric rehabilitation hospital in Canada. They may or may not have had comorbid polydipsia. They may still be inpatients currently or might have been inpatients as far back as 5 years ago. Patients' gender and ethnicity were included from the analysis.

I used the statistical power analysis software G*Power to calculate the sample size that will adequately power this research. G*Power statistical software was created at Heinrich-Heine-Universitat Dusseldorf (Buchner, 2007). I calculated the power analysis using a logistic regression statistical test with a two-tailed z test because the dependent or outcome variable was categorical. A minimum of 1,007 sample size was needed for this study. This sample size was obtained by inputting an odds ratio of 2.0, to strengthen the relationship between the independent and outcome variables. A two-tailed test of 1.95 critical value was also obtained by inputting a null hypothesis Pr (Y = 1/X = 1) Ho of .2, as well as hypothesis alpha error probability of .05 and 1-beta err probability power of 80%. This ensured that the calculated sample size met the best possible level of statistical significance at the stated critical value. An actual power of 0.8 was also a result that further buttressed the significance of the calculated sample size. These deductions afforded high effect of predicting polydipsia using weight change and hyponatremia, controlling for covariates. Table 1 shows the output of the G*Power analysis.

Table 1

*G*Power Statistical Power Analysis*

Parameter	Setting
Input	
Tail(s)	Two
Odds ration	2
Pr(Y=1|X=1) H0	0.2
α err prob	0.05
Power (1−β err prob)	0.8
R^2 other X	.1
X distribution	Binomial
X parm π	0.1
Output	
Critical z	1.9599640
Total sample size	1007
Actual power	0.8001658

Note. I performed the z tests using logistic regression. For options, I chose a large sample z-Test (Demidenko, 2007) with var corr. For analysis, I chose A priori: Compute required sample size.

Instrumentation and Operationalization of Variables

I collected data from charts of individuals currently on inpatient psychiatric rehabilitation units and archival records. I developed a polydipsia data collection tool and a master list for extracting and deidentifying data respectively. The data set comprised persons living with schizophrenia in a rehabilitation psychiatric hospital as the unit of analysis and provided data as independent variables, which was used to predict polydipsia for analysis. I used SPSS to conduct logistic regression analysis. Following computation of the logistic regression using SPSS, I was able to deduce the result to determine whether to reject the null hypothesis.

The outcome or dependent variable was polydipsia resulting from water intoxication or overhydration among persons diagnosed with schizophrenia in a

rehabilitation psychiatric facility. The covariates were age, age of onset, gender, race/ethnicity, length of stay in hospital, comorbidity, and medications. In the study, I focused on individuals with chronic schizophrenia who were inpatients in a rehabilitation psychiatric hospital in a Canadian province. The research consisted of data from existing and archival records 5 years back, which allowed for exploration of current and past findings.

Independent Variables

In this study, I used weight measures and sodium levels (particularly low sodium levels or hyponatremia) as my independent variables, and all data were obtained from patients' charts or electronic records. The weights of participants were measured in kilogram, across the day, and multiple measures were required through the day, with baseline morning weight before breakfast and after supper. Other weight measures were taken whenever there was suspicion of excessive water intake. The difference(s) in weight measures, called weight change, was the independent variable that was needed to establish this relationship. It can be counted, hence, as a continuous numerical variable.

I obtained sodium values from blood electrolytes. These values are measured in millimoles per liter. The measurement varies with excessive water intake and helps to also establish this association. This variable can neither be altered by the researcher nor the participants. It is also a continuous numerical variable. Patients included in this study must have met the diagnostic criteria of schizophrenia according to this study.

Dependent Variable

Polydipsia was the dependent or outcome variable I used in this study. I predicted it from weight changes and corresponding sodium levels of participants, particularly those suspected to have overhydrated. This was a categorical variable. Covariates for this study included age, age of onset, gender, ethnicity, duration of illness, length of hospital stay, and comorbidities in schizophrenia cases selected. I applied logistic regression to evaluate how weight change and hyponatremia best predicted polydipsia in chronic schizophrenia with comorbid water intoxication in a psychiatric hospital. Frequency was used to define each categorical variable. The relationship between the independent and dependent variables was tested by crosstab using SPSS. Other tests completed in SPSS were a chi-square test to assess the hypotheses, and the null hypotheses regarding the relationship between the dependent and independent variables were tested using the multivariate test.

Data Analysis Plan

I used logistic regression to analyze the data to determine how weight change and hyponatremia could predict polydipsia in persons with chronic schizophrenia in a psychiatric rehabilitation facility. I also analyzed using logistic regression, how weight change or hyponatremia, could independently predict polydipsia in chronic schizophrenics. In my logistic regression analysis, I used adjusted odds ratio as the measure of effect. Where applicable, linear or multiple linear regression would be used to analyze questions relating to dependent variables that were continuous data. Frequencies and percentages were determined from independent categorical variables. I included the

covariates to analyze the independent impact of weight change and/or hyponatremia on polydipsia. I adjusted the covariates that were included to mitigate the effect of confounding. SPSS was used to ease the analysis of the statistically complex data presented in this study. This software also helped to suggest the trends of the significance findings between the dependent and independent variables, as it related to the target population of study and research setting.

Threats to Validity

Selection and measurement biases were the critical threats to validity in this study because I focused on psychiatric inpatient rehabilitation facility in a Canadian province, extracting charted information obtained and measured by staff working there. By the same token, accounting for missing data and the differences within samples all through the study to protect the result, helped to mitigate the possibility of threats to internal validity.

Summary

This chapter entailed a comprehensive narrative of the research design and rationale, independent variables, dependent variable, population of study, setting and sample, calculation of sample size using G*Power, instruments and materials, research questions and hypotheses, data analysis and threats to validity.

The results of this study provided understanding on how polydipsia can be accurately predicted by weight change and hyponatremia, among persons living with schizophrenia. Therefore, this study aimed at bridging the knowledge gap of accurately screening for excessive water intake in chronic schizophrenics by focusing on the

relationship determined by measuring weight change and blood or serum sodium levels (Kirino et al., 2019).

The findings of this study bother on how polydipsia among persons living with schizophrenia was determined or identified by weight change and hyponatremia. The following covariates were assessed for their impact on the relationship between weight change and hyponatremia, and polydipsia in an inpatient psychiatric rehabilitation facility; age, age of onset, gender, ethnicity, duration of illness, length of hospital stay, and comorbidities in schizophrenic cases selected. In Chapter 3, I present the results of the study

Chapter 4: Results

Introduction

I conducted this study to more accurately and reliably screen for coexisting polydipsia in patients with schizophrenia in health care. To address the study purpose, I applied a quantitative approach to assess weight change and blood sodium levels, among other body electrolytes, in suspected cases of comorbid polydipsia in patients with schizophrenia in an inpatient unit with serious mental disorders. The RQs and hypotheses for the study were as follows:

RQ1-Quantitative: Is polydipsia associated with weight change when controlling for age, gender, age of onset, duration of illness, and length of hospital stay?

$H_0$1: Polydipsia is not associated with weight change when controlling for age, gender, age of onset, duration of illness, and length of stay.

H_a1: Polydipsia is associated with weight change when controlling for age, gender, age of onset, duration of illness, and length of stay.

RQ2-Quantitative: Is polydipsia associated with hyponatremia, when controlling for age, gender, age of onset, duration of illness, and length of hospital stay?

$H_0$2: Polydipsia is not associated with hyponatremia, when controlling for age, gender, age of onset, duration of illness, and length of hospital stay.

H_a2: Polydipsia is associated with hyponatremia, when controlling for age, gender, age of onset, duration of illness, and length of hospital stay.

RQ3-Quantitative: Is polydipsia associated with weight change and hyponatremia, when controlling for age, gender, age of onset, duration of illness, and length of hospital stay?

$H_0$3: Polydipsia is not associated with weight change and hyponatremia, when controlling for age, gender, age of onset, duration of illness, and length of hospital stay.

H_a3: Polydipsia is associated with weight change and hyponatremia, when controlling for age, gender, age of onset, duration of illness, and length of hospital stay.

In this chapter, I furnish results of the descriptive statistical analysis of data I collected from charts of current inpatients charts and previous inpatient archival records.

Data Collection

A total of 1,068 cases met the inclusion criteria after data entry. However, the variables of interest were missing in 1,040 participants' charts or records. Although I performed descriptive statistics for nearly all the variables, only the participants' records that had no missing data of interest were statistically analyzed to obtain accurate and reliable result of this study. My analysis was done using IBM SPSS Statistics Version 26. Further, I created the following variables to enable my analysis.

- blood electrolyte measure (BEM), that is, BEM Na1, BEM Na2, BEM Na3 and BEM Na4;
- urine specific gravity (USG), that is USG1, USG2, USG3 and USG4;
- weight measurement (WTA), that is, WT1A, WT2A, WT3A and WT4A; and

- weight measurement (WTB), that is, WT1B, WT2B, WT3B and WT4B.

I collected this information at four time points:

Hyponatremia

I created the variable hyponatremia from the sodium (Na) level of the BEM. Each respondent's first time point was used in creating the hyponatremia variable. BEM_Na responses were recoded as 1 and 0. A sodium (Na) measurement below 135 mmol/L (< 135 mmol/L) was coded as 1 as an indicator for the presence of hyponatremia; all other responses were coded as 0.

Polydipsia

I created the variable polydipsia from USG. Each respondent's first time point was used in creating the polydipsia variable. BEM responses were recoded as 1 and 0. The code 1, which represents over hydration, was used as an indicator for the presence of polydipsia; all other responses were assigned 0.

Weight Change

I created the variable weight change from the difference in Weight Measurement A and Weight Measurement B (WTA-WTB) for each respondent's first time point.

Results

Descriptive Statistics

Frequencies for Categorical Variables

Table 2 represents the descriptive statistical output data for sex or gender of the participants for this study. Of the 1,068 participants whose charts or records were

examined, 834 (78.1%) were reported as males, and 225 (21.1%) were recorded as females, while in nine (0.8%) cases, the data were missing on sex or gender.

Table 2

Frequency Distribution of Sex of Study Participants

Sex	*n*	%
Female	225	21.1
Male	834	78.1
Missing	9	.8
Total	1,068	100.0

Male gender was three times more represented than female gender, despite nine cases being missing

Table 3 represents the descriptive statistical data output of the ethnic backgrounds of the total 1,068 participants of the study. In the analysis, 359 (33.6%) were Whites, 367 (34.4%) were Indigenous, 23 (2.2%) were Metis, 12 (1.1%) were Asian, 12 (1.1%) were Black, 9 (0.8%) were Indian, 6 (0.6%) were Hispanic, 5 (0.5%) were Inuit, 1 (0.1%) was Filipino. A significant proportion, 257 (24.1%), had unknown ethnicity, while in 17 (1.6%) charts, the ethnic backgrounds of participants were missing.

Table 3

Frequency Distribution of Ethnicity of Study Participants

Ethnicity	*n*	%
Asian	12	1.1
Black	12	1.1
Hispanic	6	.6
Indian	9	.8

Indigenous	367	34.4
Inuit	5	.5
Metis	23	2.2
Filipino	1	.1
White	359	33.6
Unknown	257	24.1
Missing	17	1.6
Total	1,068	100.0

Indigenous and White ethnic groups were by far the most represented groups.

Table 4 shows the descriptive statistics output data of illness duration of the 1,068 participants involved in this study. As shown in the table, 395 (37.0%) had suffered from schizophrenia and/or a psychotic disorder for over 10 years; 466 (43.6%) of the 1,068 participants lived with schizophrenia and/or psychotic disorder for less than 10 years. In 186 (17.4%) of the participants, the data on duration of illness was missing from their charts or records.

Table 4

Frequency Distribution of Illness Duration of Study Participants

Illness Duration	Frequency (n)	Percent (%)
Less than ten years	466	43.6
Ten or more years	395	37.0
Unknown	186	17.4
Missing	21	2.0
Total	1068	100.0

Nearly four hundred participants have been chronically ill for ten years or more

Table 5 indicates descriptive statistical output data of length of hospital stay of 1068 participants in this study. 920(86.1%) of the participants were inpatients for less

than 5 years. 105(9.8%) were inpatients for 10 years or more. In 19(1.8%) of the participants' charts or records, the indication of their length of stay was unknown. The data on length of stay was missing in 24(2.2%) charts or records.

Table 5

Frequency Distribution of Length of Stay of Study Participants

Length of stay	Frequency (n)	Percent (%)
Inpatients for less than 5 years	920	86.1
Inpatients for 10 years or more	105	9.8
Unknown	19	1.8
Missing	24	2.2
Total	1068	100.0

Over a thousand had lengthy stay with over a hundred staying ten years or more

Table 6 represents the descriptive statistical data output of the first time point information of the USG (USG1) of 1,068 participants in this study. One hundred and fifty three (14.3%) of them were overhydrated. 119 (11.1%) of them were euhydrated or had normal levels of hydration. The marginally hydrated were 87(8.1%). Those who were hypohydrated were 47(4.4%). The severely hypohydrated were 10(0.9%), while the clinically dehydrated were 6(0.6%). The data for the levels of hydration for USG1 were missing in 646(60.5%) of the participants' charts or records in this study

Table 6

Frequency Distribution for the First Measure of Urinary Specific Gravity (USG1) of Study Participants

USG1	Frequency (n)	Percent (%)

1.005-1.012 overhydrated	153	14.3
1.013-1.015 euhydrated	119	11.1
1.016-1.020 marginally hydrated	87	8.1
1.021-1.025 hypohydrated	47	4.4
1.026-1.029 severely hypohydrated	10	.9
>1.030 clinically dehydrated	6	.6
Missing	646	60.5
Total	1068	100.0

Over a hundred and fifty participants were overhydrated from USG1 measurement

Table 7 shows the second time point descriptive statistical output data of USG (USG2) of the 1,068 participants in this study. Sixty two (5.8%) were captured as overhydrated. Forty seven (4.4%) were recorded as euhydrated. The marginally hydrated were 32 (3.0%) of the 1068 participants. 11(1.0%) were hypohydrated. 6 (0.6%) were severely hypohydrated. 4 (0.4%) were clinically dehydrated. In 906 (84.8%) of the participants, the data on the USG2 were missing.

Table 7

Frequency Distribution for the Second Measure of Urinary Specific Gravity (USG2) of Study Participants

USG2	frequency (n)	Percent (%)
1.005-1.012 overhydrated	62	5.8
1.013-1.015 euhydrated	47	4.4
1.016-1.020 marginally hydrated	32	3.0
1.021-1.025 hypohydrated	11	1.0
1.026-1.029 severely hypohydrated	6	.6
>1.030 clinically dehydrated	4	.4
Missing	906	84.8
Total	1068	100.0

Over sixty participants were overhydrated from USG2 measurement

Table 8 represents descriptive statistical data output for the third time point information of USG (USG3) of 1,068 participants in this study. Twenty nine (2.7%), 29 (2.7%), 13 (1.2%), 5 (0.5%), 1 (0.1%), and 2 (0.2%) were overhydrated, euhydrated, marginally hydrated, hypoydrated, severely hypohydrated and clinically dehydrated, respectively. USG3 information was missing in 989 (92.6%) of participants' records in this study.

Table 8

Frequency Distribution for the Third Measure of Urinary Specific Gravity (USG3) of Study Participants

USG3	Frequency (n)	Percent (%)
1.005-1.012 overhydrated	29	2.7
1.013-1.015 euhydrated	29	2.7
1.016-1.020 marginally hydrated	13	1.2
1.021-1.025 hypohydrated	5	.5
1.026-1.029 severely hypohydrated	1	.1
>1.030 clinically dehydrated	2	.2
Missing	989	92.6
Total	1068	100.0

Nearly 30 participants were overhydrated from USG3 measurement

Table 9 represents descriptive statistical output data of the fourth time point data information of urinary specific data (USG4) of the 1068 participants in this study. Those who were overhydrated, euhydrated, marginally hydrated, hypohydrated, severely hypohydrated, and clinically dehydrated were 20(1.9%), 13(1.2%), 4(0.4%), 4(0.4%),

1(0.1%) and 1(0.1%), respectively. However, the USG4 data were missing in 1,025 (96.0%) charts or records.

Table 9

Frequency Distribution for the Fourth Measure of Urinary Specific Gravity (USG4) of Study Participants

USG4	Frequency (n)	Percent (n)
1.005-1.012 overhydrated	20	1.9
1.013-1.015 euhydrated	13	1.2
1.016-1.020 marginally hydrated	4	.4
1.021-1.025 hypohydrated	4	.4
1.026-1.029 severely hypohydrated	1	.1
>1.030 clinically dehydrated	1	.1
Missing	1025	96.0
Total	1068	100.0

Up to twenty participants were overhydrated from USG4 measurement

Table 10 represents descriptive statistical output data of the 1068 participants in this study for age of onset, age, blood electrolyte sodium measurements for all the four time points (BEM1Na, BEM2Na, BEM3Na and BEM4Na), and weight difference for all the four time points as well (WT1A and B, WT2A and B, WT3A and B, and WT4A and B).

Table 10

Descriptive Statistics of Continuous Variable

Variable	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Age of Onset	759	1.000	61.000	22.570	8.447	71.359

Age	1040	14.000	71.000	32.900	11.255	126.669
BEM1Na	463	102.000	149.000	140.410	4.222	17.827
BEM2Na	188	42.000	150.000	139.970	7.894	62.320
BEM3Na	114	14.000	147.000	138.720	15.234	232.062
BEM4Na	65	129.000	149.000	140.170	3.130	9.799
WT1A	420	40.820	172.000	82.565	18.732	350.906
WT1B	72	51.200	139.500	84.740	17.457	304.732
WT2A	134	54.430	185.000	84.893	18.223	332.098
WT2B	20	67.500	139.250	92.551	19.777	391.129
WT3A	54	53.980	125.000	87.395	16.459	270.911
WT3B	9	75.750	124.000	93.837	16.438	270.193
WT4A	38	50.000	750.000	103.168	109.319	11950.729
WT4B	8	68.500	121.110	87.605	17.223	296.649

BEM1Na, BEM2Na, BEM3Na and BEM4Na are the blood electrolyte sodium measurements for all the four time points. WT1A, WT2A, WT3A, and WT4A are the first weight measure for all the four time points. WT1B, WT2B, WT3B, and WT4B are the second weight measure for all the four time points

There were 759 participants' charts that had age of illness, minimum of 1, maximum of 61, a mean of 22.57, a standard deviation of 8.447 and a variance of 71.359. The ages of 1040 were captured of the 1068 participants in this study with a minimum of 14, a maximum of 71, a mean of 32.90, a standard deviation of 11.255 and a variance of 126.669. The BEM1Na was reported in only 463 of 1068 participants' records with a minimum of 102, a maximum of 149, a mean of 140.41, a standard deviation of 4.222

and a variance of 17.827. BEM2Na was captured in 188 participants' record with a minimum of 42, a maximum of 150, a mean of 139.97, a standard deviation of 7.894 and a variance of 62.320. BEM3Na was indicated in 114 of 1068 participants' records with a minimum of 14, a maximum of 147, a mean of 138.72, a standard deviation of 15.234, and a variance of 232.062. BEM4Na was captured in only 65 participants' charts or records with a minimum of 129, a maximum of 149, a mean of 140.17, a standard deviation of 3.130, and a variance of 9.799.

The WT1A was reported on 420 participants' charts with a minimum of 40.820, maximum of 172.000, mean of 82.56515, a standard deviation of 18.732486 and a variance of 350.906. WT1B was captured in 72 charts with a minimum of 51.20, maximum of 139.50, mean of 84.7404, standard deviation of 17.45657 and a variance of 304.732. There 134 charts in which WT2A was captured, with minimum of 54.43, maximum of 185.00, mean of 84.8929, standard deviation of 18.22356, and a variance of 332.098. WT2B was reported on 20 charts with a minimum of 67.500, maximum of 139.253, a mean of 92.55065, a standard deviation of 19.776971, and variance of 391.129. WT3A was obtained on 54 charts with a minimum of 53.98, maximum of 125.00, a mean of 87.3950, a standard deviation of 16.45938, and a variance of 270.911. WT3B information was reported on 9 participants' records with a minimum of 75.75, a maximum of 124.00, a mean of 93.8367, a standard deviation of 16.43755, a variance of 270.193. In 38 charts, WT4A was reported on 38 charts, with a minimum of 50.00, maximum of 750.00, a mean of 103.1679, a standard deviation of 109.31939 and a variance of 11950.729. Lastly, WT4B was captured on 8 charts with a minimum of

68.50, maximum of 121.11, a mean of 87.6050, a standard deviation of 17.22351 and a variance of 296.649.

Histograms Describing the Distribution of the Continuous Variable of Interest

Figure 1 shows a simple histogram of the continuous variable distribution of the age of onset and frequencies of 759 participants in this study with a mean of 22.57 and standard deviation of 8.447.

Figure 1

Age of Onset

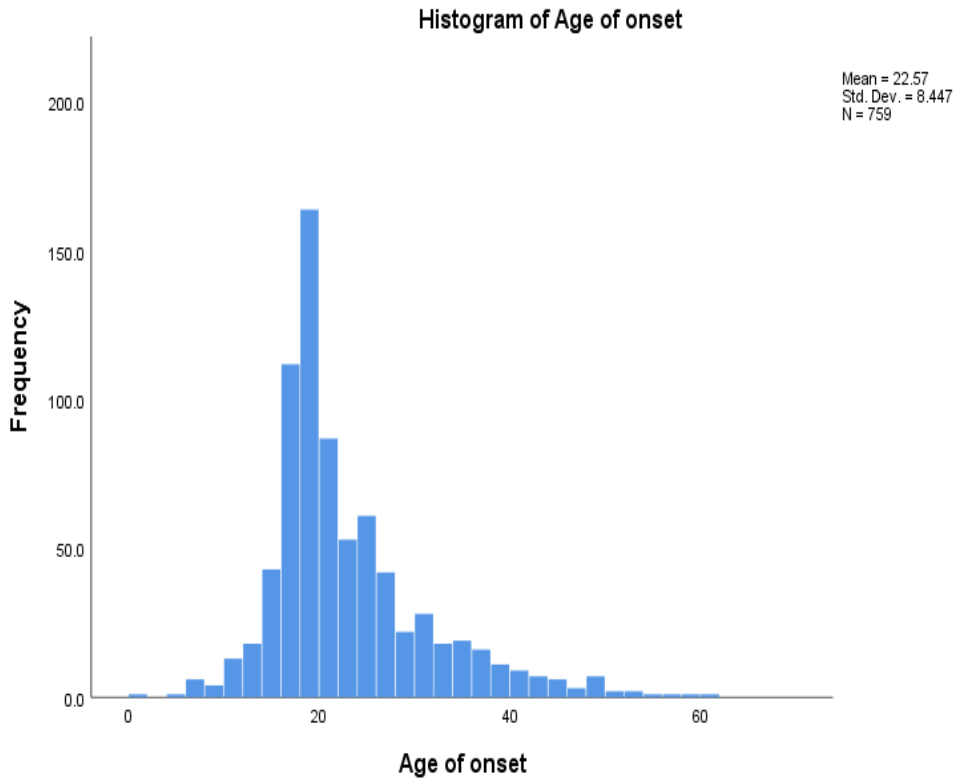


Figure 2 represents a simple histogram of continuous variable distribution of the ages and frequencies of 1040 participants in this study with a mean of 32.90 and a standard deviation of 11.255.

Figure 2

Age of Participants

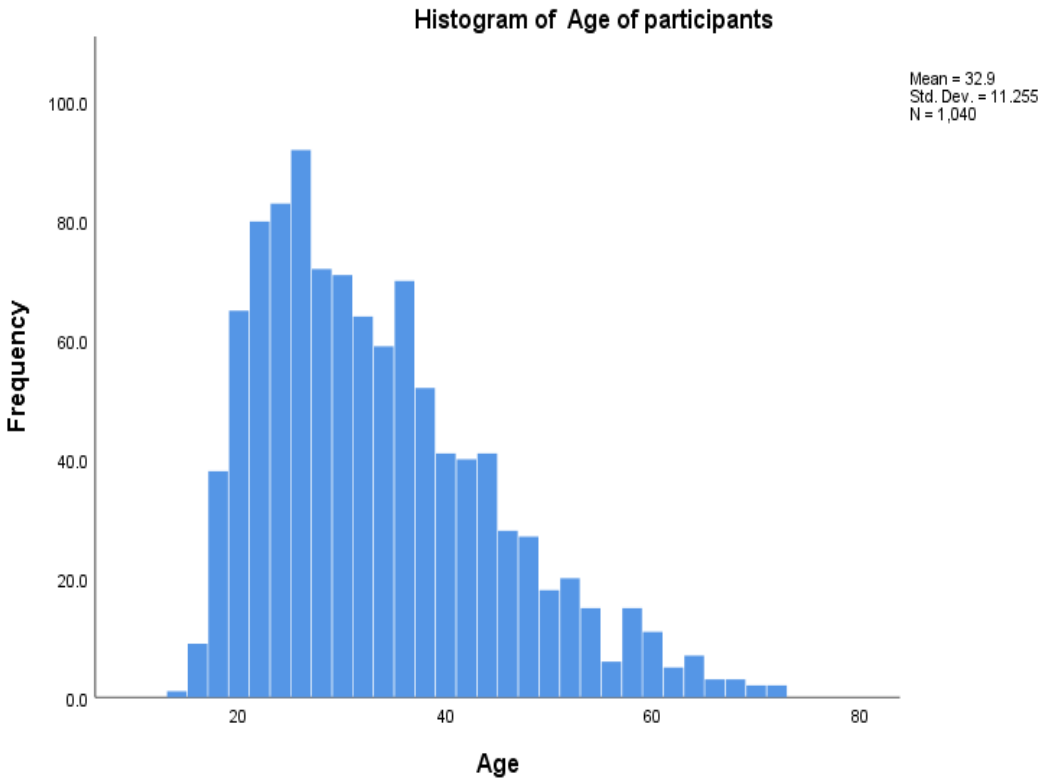


Figure 3 shows a simple histogram of continuous variable distribution of BEM1Na and frequencies of 463 participants in this study with a mean of 140.41 and a standard deviation 4.222.

Figure 3

Histogram of Blood Electrolyte Sodium Measurements for First Time Points

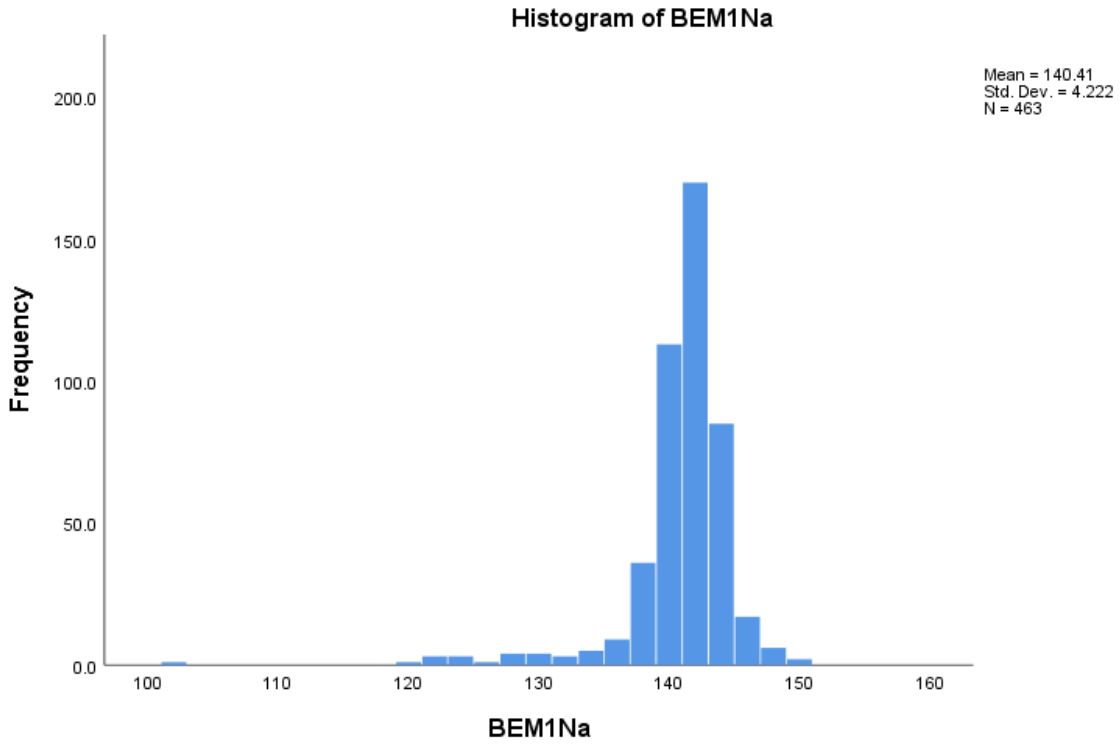


Figure 4 represents a simple histogram of continuous variable distribution of BEM4Na and frequencies of 65 participants in this study with a mean of 140.17 and a standard deviation 3.130.

Figure 4

Histogram of Blood Electrolyte Sodium Measurements for Fourth Time Points

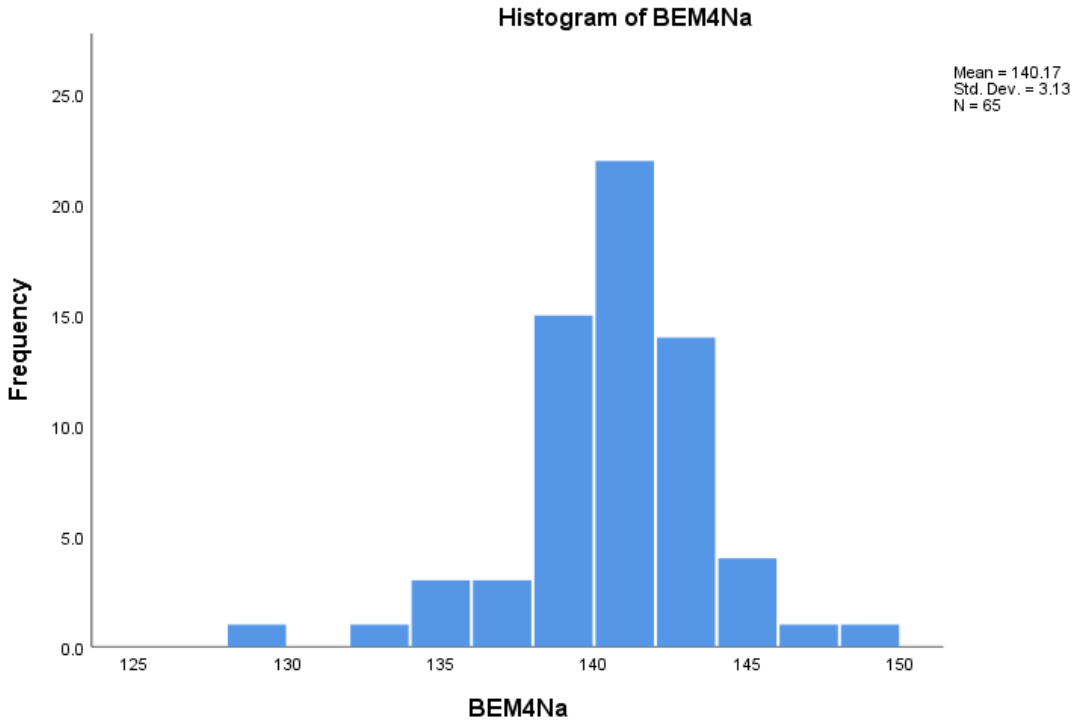


Figure 5 shows a simple histogram of continuous variable distribution of WT1A and frequencies of 420 participants in this study with a mean of 82.56515 and a standard deviation of 18.732486.

Figure 5

Histogram of First Weight Measure for First Time Points

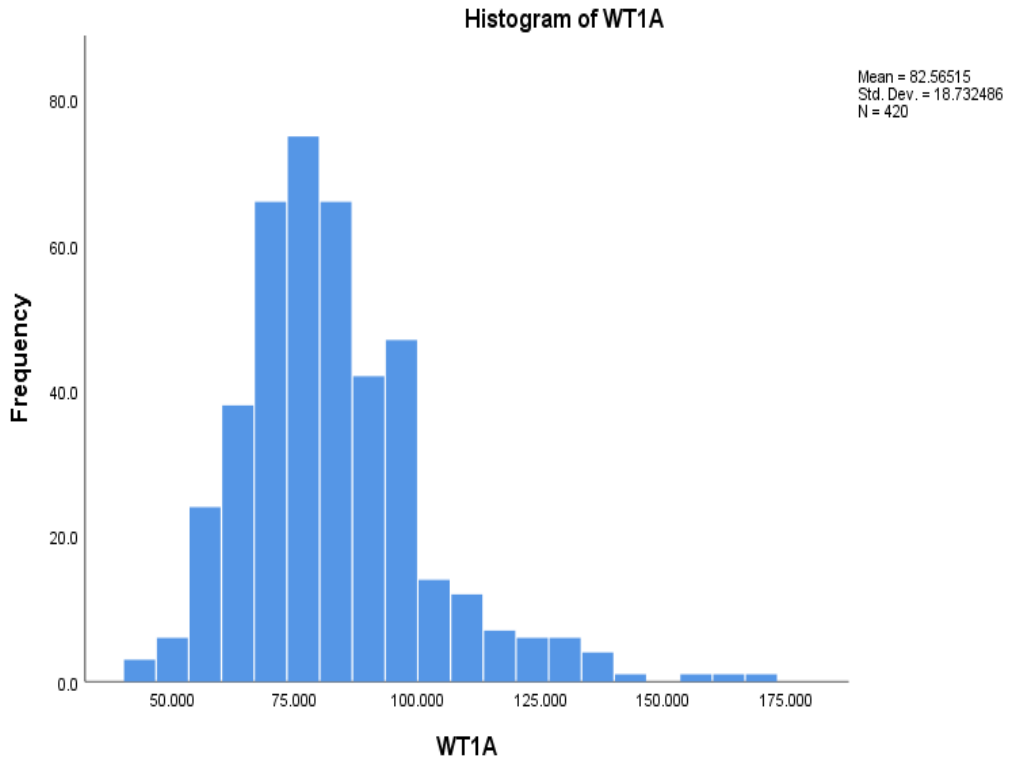


Figure 6 shows a simple histogram of continuous variable distribution of WT1B and frequencies of 72 participants in this study with a mean of 84.7404 and a standard deviation 17.45657.

Figure 6

Histogram of Second Weight Measure for First Time Points

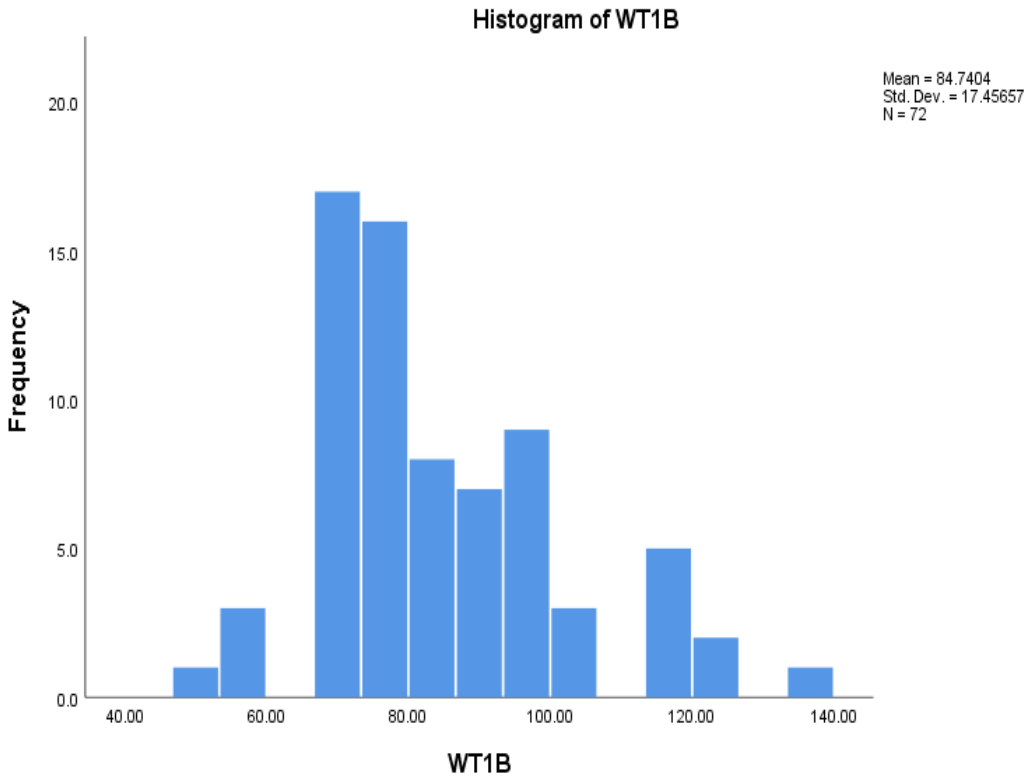


Figure 7 shows a simple histogram of continuous variable distribution of WT2A and frequencies of 134 participants in this study with a mean of 84.893 and a standard deviation 18.224.

Figure 7

Histogram of First Weight Measure for Second Time Points

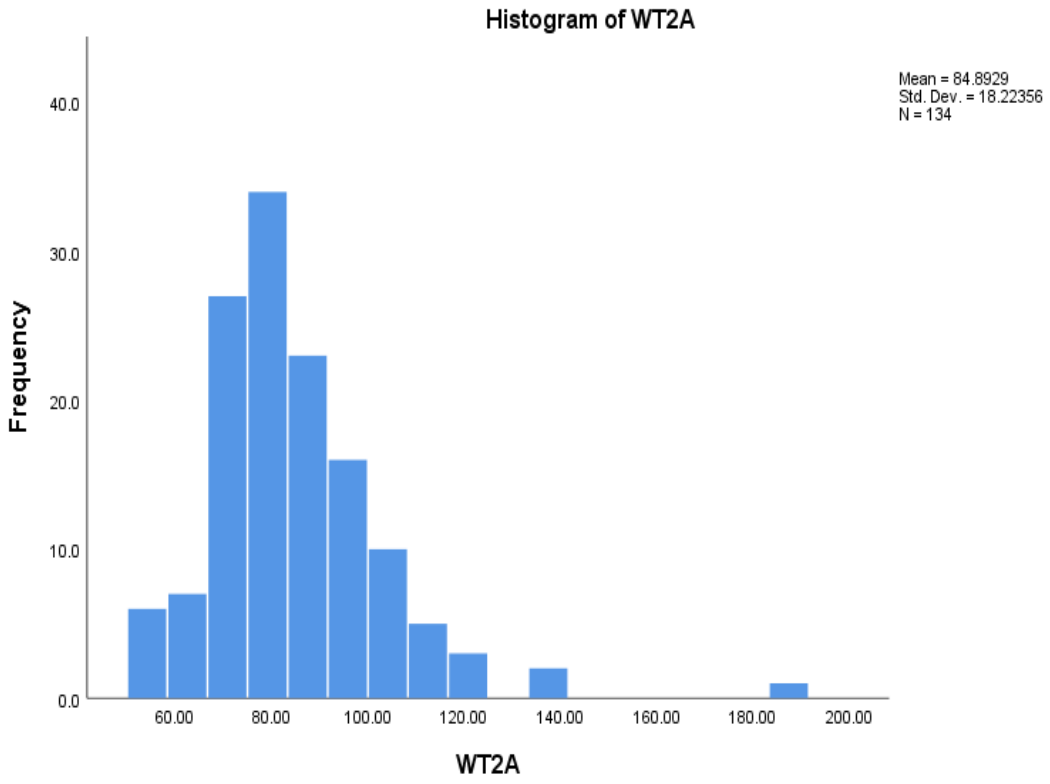


Figure 8 represents a simple histogram of continuous variable distribution of WT2B and frequencies of 20 participants in this study with a mean of 92.551 and a standard deviation 19.777.

Figure 8

Histogram of Second Weight Measure for Second Time Points

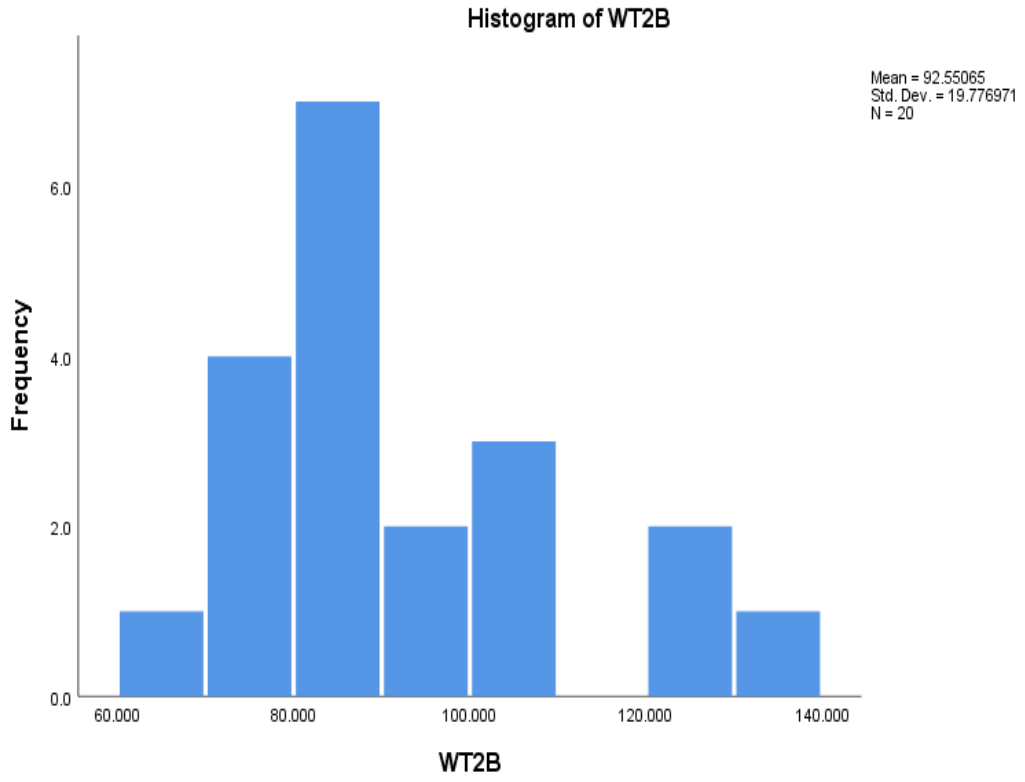


Figure 9 shows a simple histogram of continuous variable distribution of WT3A and frequencies of 54 participants in this study with a mean of 87.395 and a standard deviation 16.460.

Figure 9

Histogram of First Weight Measure for Third Time Points

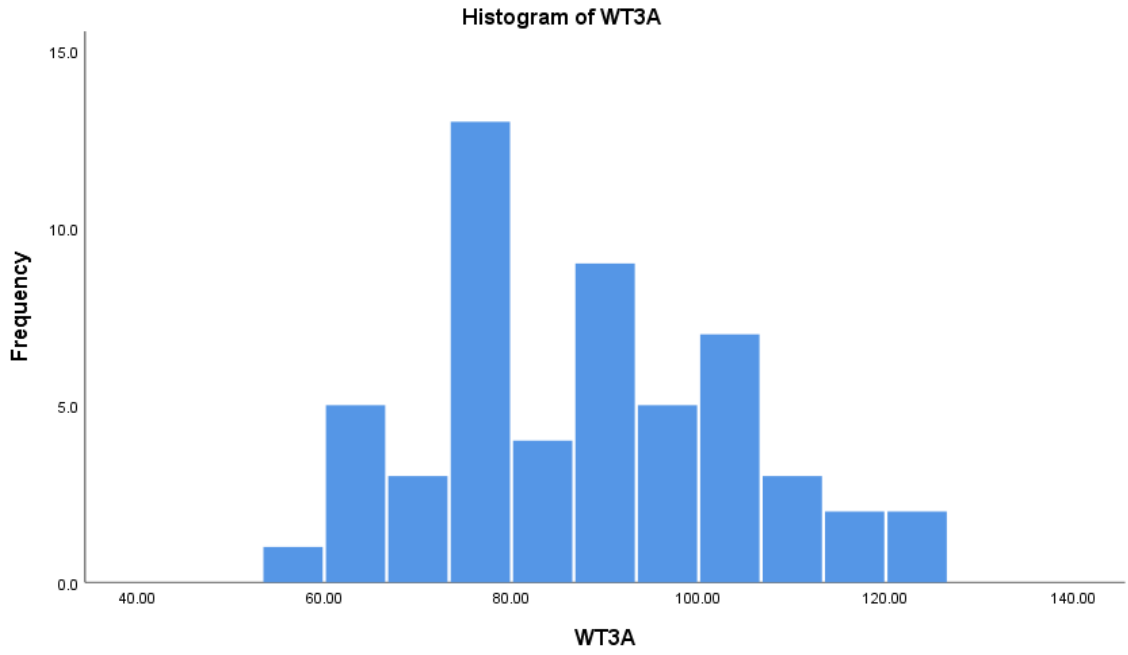


Figure 10 represents a simple histogram of continuous variable distribution of WT3B and frequencies of 9 participants in this study with a mean of 93.8367 and a standard deviation 16.43755.

Figure 10

Histogram of Second Weight Measure for Third Time Points

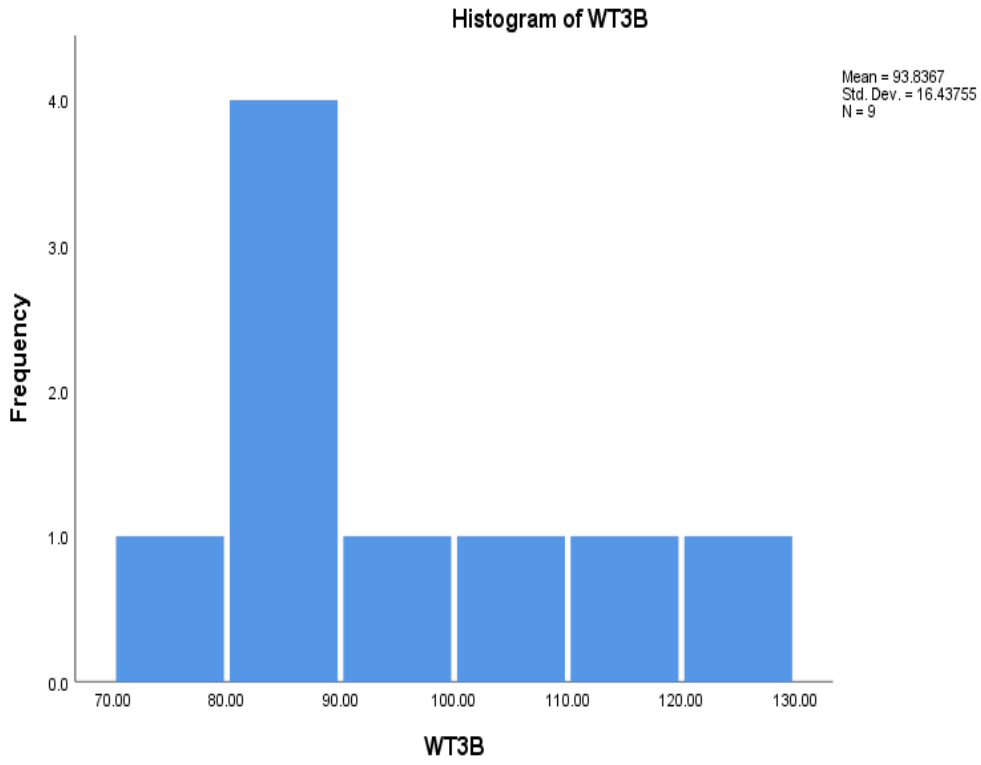


Figure 11 shows a simple histogram of continuous variable distribution of WT4A and frequencies of 38 participants in this study with a mean of 103.1679 and a standard deviation 109.31939.

Figure 11

Histogram of First Weight Measure for Fourth Time Points

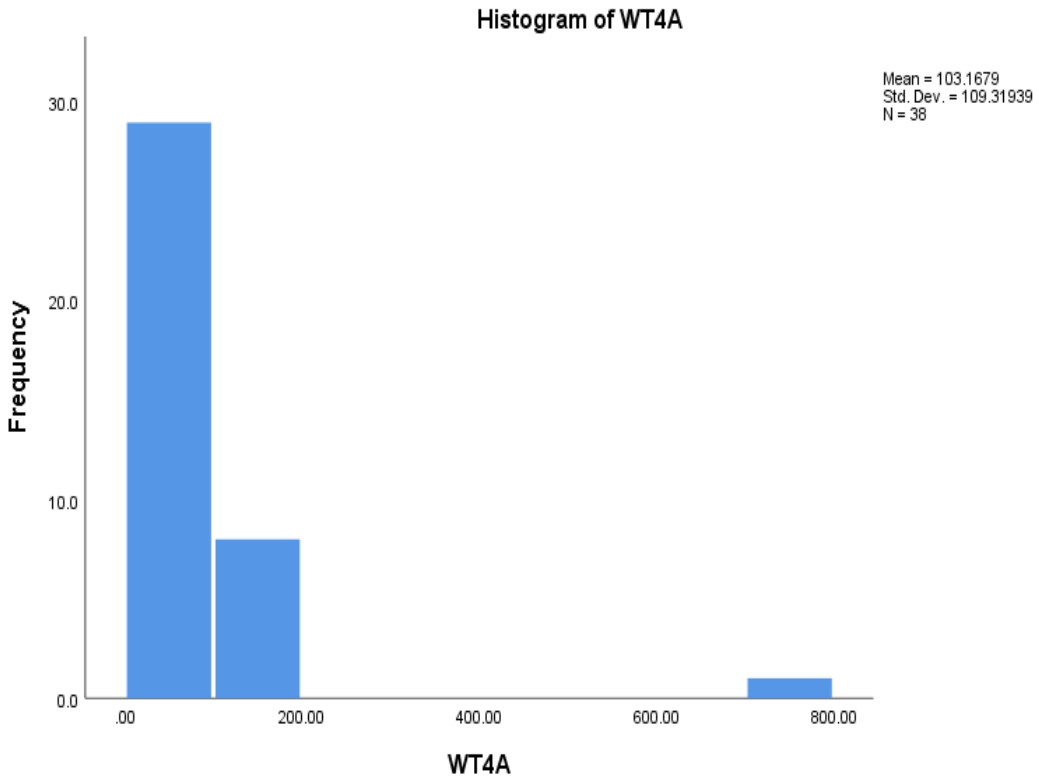
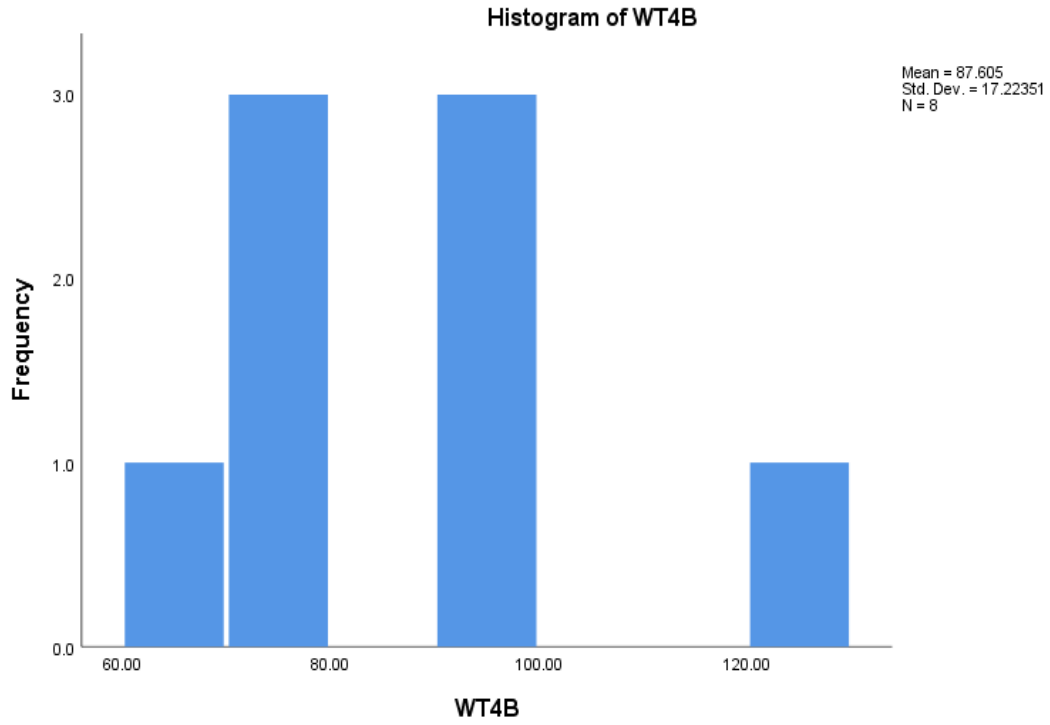


Figure 12 shows a simple histogram of continuous variable distribution of WT4B and frequencies of 8 participants in this study with a mean of 87.605 and a standard deviation 17.22351

Figure 12

Histogram of Second Weight Measure for Fourth Time Points



Inferential Analysis

The total sample considered for analysis is 48, after removing missing responses. Three logistic regression models were fitted. The dependent variable for all three models was polydipsia. In Model 1, I sort to establish the association between polydipsia and weight change, while controlling for age, ethnicity, illness duration and length of stay. Model 2 examined the association between polydipsia and hyponatremia while controlling for age, ethnicity, illness duration and length of stay. While Model 3 considered the association between polydipsia with the combined effects of weight change and hyponatremia while controlling for age, ethnicity, illness duration and length of stay.

Table 11

Cross-tabulation Results of Polydipsia and the Categorical Variables used in the Logistic Regression Models

Variables		Polydipsia						Significance
		Yes		No		Total		
		N	%	N	%	N	%	
Sex	Female	6	20.7	6	31.6	12	25.0	χ^2= .726, p=.394
	Male	23	79.3	13	68.4	36	75.0	
Ethnicity	Indigenous	13	44.8	7	36.8	20	42.0	χ^2=.464, p=.793
	White	13	44.8	9	47.4	22	46	
	Others	3	10.3	3	15.8	6	13	
Length of Stay	Less than 5 years	18	62.1	13	68.4	31	65	χ^2=.202 , p=.653
	5 years or more	11	37.9	6	31.6	17	35	
Illness Duration	less than ten years	13	44.8	5	26.3	18	38	χ^2=1.678, p=.195
	Ten years or more	16	55.2	14	73.7	30	63	
Hyponatremia	0 = no	28	96.6	3	15.8	31	65	χ^2=32.734 , p<0.001
	1 = yes	1	3.4	16	84.2	17	35	

Logistic regression analysis revealed hyponatremia variable to be statistically significant

Table 12

Descriptive Statistics of the Continuous Variable Used in the Logistic Regression Model

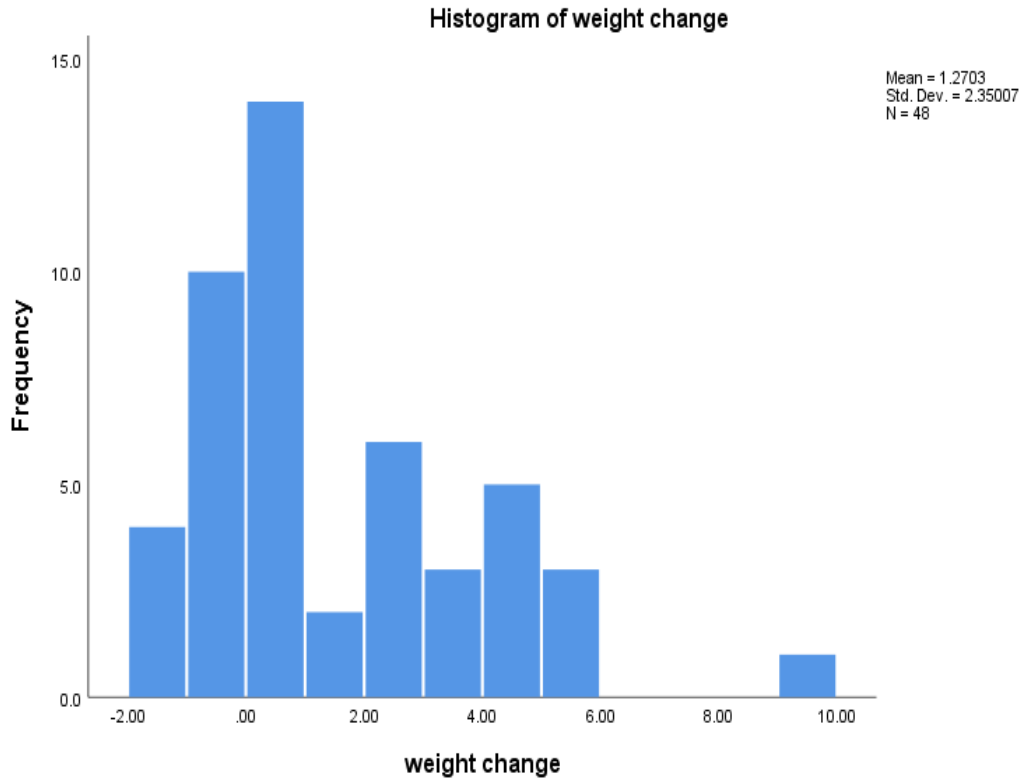
	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Age	48	18	67	32.44	12.025	144.592
Weight Change	48	-2.00	9.98	1.2703	2.35007	5.523

Age and weight were continuous data that included in the analysis

Figure 13 shows a simple histogram of continuous variable distribution of weight change and frequencies of 48 participants in this study with a mean of 1.2703 and a standard deviation 2.35007.

Figure 13

Histogram of Weight Change



Variables Excluded From Analysis

Age of Onset. The variable age of onset was excluded from the analysis because 31 out of the 48 (64.6%) samples were missing.

Sex. When sex was included in the models as a control variable, it was observed that the models had convergence issues as well as very large standard errors. I further explored the relationship between polydipsia and sex by performing a chi-squared test of association. The chi-squared test of association assumption that no cell should have an expected count less than 5 was not met. One of the cells had an expected count of 4.8.

Based on the above reason, the variable sex was excluded from the models as control variable

Logistic Regression Models

Table 13

The Association Between Polydipsia and Weight Change Controlling for Age, Ethnicity, Duration of Illness, and Length of Stay

Variable	B	S.E.	p-value	OR	95% C.I for OR	
					Lower	Upper
Weight Change	0.415	0.171	0.015	1.515	1.083	2.117
Age	0.067	0.039	0.084	1.070	0.991	1.154
Illness Duration	-0.774	0.872	0.375	0.461	0.083	2.548
Length of Stay	1.276	0.859	0.138	3.581	0.665	19.288
White Ethnicity	-0.589	1.061	0.579	0.555	0.069	4.437
Other Ethnicities	-0.835	1.079	0.439	0.434	0.052	3.597
Constant	-3.104	1.705	0.069	0.045		

Establishing statistically significant association between weight change and polydipsia

Model 1

The overall model was statistically significant, χ^2=14.112, df=6, p=.028. The model correctly classified approximately 79.2% of the cases. The "pseudo" R estimate indicates that the model explained between 25.5% (Cox Snell R squared) and 34.5% (Nagelkerke R squared) of the variance in polydipsia. The Hosmer Lemeshow test of goodness of fit suggests the model is a good fit to the data, p = .661 (>.05). Controlling for Age, Ethnicity (White and other), duration of illness and length of stay the association

between polydipsia and weight change is positive and significant (β_{weight_change}= .415, p=.015) indicating that increase in weight difference is associated with increased odds of polydipsia. The odds ratio for weight change is 1.515, which implies that for every one-unit increase in weight change, the odds of having polydipsia versus not having polydipsia is multiplied by about a factor of 1.5 while controlling for Age, White Ethnicity, other Ethnicities, illness duration and length of stay. Further, this means every one-kilogram increase in weight in a suspicious case of overhydration, proportionately predicts polydipsia in schizophrenia, one and a half times. Conversely, Age, White Ethnicity, other Ethnicities, illness duration and length of stay with odds ratios of 1.070, 0.555, 0.434, 0.461, and 3.58, did not show any statistically significant association with polydipsia as shown in Table 14.

Table 14

The Association Between Polydipsia and Hyponatremia Controlling for Age, Ethnicity, Duration of Illness, and Length of Stay

Variable	B	S.E.	p-value	OR	95% C.I. for OR	
					Lower	Upper
Hyponatremia	-6.103	1.671	0.000	0.002	0.000	0.059
Age	0.087	0.072	0.229	1.091	0.947	1.258
Illness Duration	-1.343	1.564	0.390	0.261	0.012	5.594
Length of Stay	2.087	1.622	0.198	8.063	0.336	193.712
White Ethnicity	-0.505	2.057	0.806	0.604	0.011	34.021
Other Ethnicities	0.227	2.120	0.915	1.255	0.020	79.998
Constant	-0.198	2.546	0.938	0.820		

Establishing statistically significant association between hyponatremia and polydipsia

Model 2

The overall model was statistically significant, χ^2=43.233, df=6, p<.001. The model correctly classified approximately 93.8% of the cases. The "pseudo" R estimate indicates that the model explained between 59.4% (Cox Snell R squared) and 80.4% (Nagelkerke R squared) of the variance in polydipsia. The Hosmer Lemeshow test of goodness of fit suggests the model is a good fit to the data, p = .50 (>.05). Controlling for Age, White Ethnicity, other Ethnicities, duration of illness and length of stay the association between polydipsia and hyponatremia is significant ($\beta_{\text{weight change}}$= -6.103, p<0.001). The odds ratio for hyponatremia is 0.002, which implies that for those with hyponatremia the odds of having polydipsia is 99.8% lower than the odds for those without polydipsia. By the same token, Age, White Ethnicity, other Ethnicities, duration of illness and length of stay did not attain statistically significant association with polydipsia as shown in Table 15.

Table 15

The Association Between Polydipsia and Weight Change and Hyponatremia Combined Controlling for Age, Ethnicity, Duration of Illness, and Length of Stay

Variable	B	S.E.	p-value	OR	95% C.I.for OR	
					Lower	Upper
Weight Change	0.168	0.285	0.556	1.183	0.676	2.068
Hyponatremia	-5.939	1.694	0.000	0.003	0.000	0.073
Age	0.100	0.081	0.215	1.105	0.944	1.294
Illness Duration	-1.412	1.636	0.388	0.244	0.010	6.021
Length of Stay	2.304	1.700	0.175	10.017	0.358	280.209
White Ethnicity	-0.771	2.068	0.709	0.463	0.008	26.667
Other Ethnicities	0.040	2.072	0.985	1.041	0.018	60.467
Constant	-0.778	2.707	0.774	0.459		

Combined effect of weight change and hyponatremia on predicting polydipsia

Model 3

Model 3 concerned the effect of weight change and hyponatremia on polydipsia while controlling for age, White ethnicity, other ethnicities, duration of illness and length of stay, it is observed that. The overall model was significant, $\chi^2 = 43.533$, df = 7, p <.001. The model correctly classified approximately 93.8% of the cases. The "pseudo" R estimate indicates that the model explained between 59.6% (Cox Snell R squared) and 80.7% (Nagelkerke R squared) of the variance in polydipsia. The Hosmer Lemeshow test of goodness of fit suggests the model is a good fit to the data, p = .17 (>.05). In this model, the effect of weight change is not significant (p=0.556) however, hyponatremia is significant (p<0.001). Although this finding might be surprising but not unusual, even though weight change and hyponatremia attained statistically significant association with polydipsia when independently analyzed in models 1 and 2 respectively. Once again, Age, White Ethnicity, other Ethnicities, duration of illness and length of stay did not attain statistical significance as shown in Table 16.

Summary

Individually, I observed a significant relationship between polydipsia and weight change and polydipsia and hyponatremia when controlling for Age, White Ethnicity, other Ethnicity, illness duration and length of stay in each model. However, when I considered the association between polydipsia with both weight change and hyponatremia as covariates in the same model controlling for the same variables, I observed that weight change is not significant, but hyponatremia is significant. There is

therefore evidence of confounding. For a variable to be a confounder, it must be related to both the outcome variable and exposure of interest. The confounding variable is hyponatremia. Model 2 confirms the relationship between hyponatremia and polydipsia. To learn the relationship between hyponatremia and weight change an independent t-test is performed. The result of the independent t-test show a significant relationship between hyponatremia and polydipsia, *t(46)=-3.432, p=0.001*. Further, to determine whether hyponatremia is a confounding variable for weight change, I compared the adjusted and unadjusted estimates. If they are significantly different, confounding is present, and the confounding variable must be included in the model; the rule of thumb is

$$\left|\frac{\beta_{unadjusted} - \beta_{adjusted}}{\beta_{unadjusted}}\right| \times 100\% \; > \; 20\% .$$

In this case,

$\beta_{unadjusted}$ is the β estimate of weight change in Model 1.

$\beta_{adjusted}$ is the β estimate of weight change in Model 3.

$$\left|\frac{0.416 - 0.168}{0.416}\right| \times 100\% \; = \; 59.6\% \; > 20\% .$$

So, I would conclude that hyponatremia is confounding with weight change. Table 16 includes the variables in the data set.

Table 16

Variables in the Data Set

Variable	Variable name in data set

Polydipsia	Polydipsia
Hyponatremia	Hyponatremia
Weight change	weight_change
Illness duration	IllnessDuration_dicat
Length of stay	lengthofStay_dicat
Ethnicity (White and others)	ethnicity_cat

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

The purpose of this study was to explore how weight change and hyponatremia could better accurately and reliably detect coexisting polydipsia in individuals with schizophrenia in psychiatric inpatient units. Study findings may help health care workers to improve the identification or detection of a comorbid polydipsia in schizophrenia. My objective was to examine whether coexisting polydipsia in persons with schizophrenia could be accurately and reliably predicted by using weight change and blood sodium levels. Wilson's complexity theory was applied to guide this study. This public health theory, which emerged in the 20th century, can be used to unravel unpredictable patterns of behaviors resulting from compromised complex biological and social systems (Dunn & Riley-Doucet, 2017). The findings from cross tabulations and three logistic regression models revealed interesting statistically significant relationships between the independent and dependent variables of interest. In this chapter, I interpret the findings and discuss the limitations encountered during this research. I will also provide recommendations for future research and discuss the study's application to professional practice and implications for positive social change.

Interpretation of the Findings

The outcomes of this quantitative research indicate that weight change and hyponatremia were statistically significant variables, as well as the combined effect of their relationship. Results from the three logistic regression models showed significance with *p* values of .015, .000, and less than .001 for weight change, hyponatremia, and the

combined effect of weight change and hyponatremia. These values supported the rejection of the null hypotheses and validated the conjecture that in persons with schizophrenia, weight change is associated with polydipsia, hyponatremia is associated with polydipsia, and the combined effect of weight change and hyponatremia is also associated with polydipsia, when controlling for age, White ethnicity, other ethnicities, duration of illness, and length of stay.

With an odds ratio (OR) of 1.515 for weight change variable, the odds of having polydipsia compared to not having polydipsia in persons with schizophrenia was more than one and half times, for unit increase in weight change when controlling for age, ethnicity, duration of illness, and length of stay. By the same token, hyponatremia variable has an odds ratio of 0.002. Hence, in persons with schizophrenia, the odds of having hyponatremia and polydipsia are 99.8% less than for those without polydipsia when controlling for age, ethnicity, duration of illness, and length of stay.

In this study interestingly, the independent variables weight change and hyponatremia, as well as the combined effect of their relationship, appeared to be strong predictors of polydipsia in persons with schizophrenia, when controlling for age, White ethnicity, other ethnicities, duration of illness, and length of stay. These findings further support rejecting the null hypotheses. Weight change is obtained from weight measurements at different times, and it is a simple noninvasive routine essential bedside vital sign measure done for inpatients or outpatients. The frequency of requiring or requesting weight measurement(s) for any hospital patient depends on the need.

Limitations of the Study

The charts or electronic records for participants for this study were conveniently picked, and there was no randomization; hence there was selection bias. I focused on participants diagnosed within the schizophrenia spectrum and other psychotic disorders and only looked at these records. This may be a limitation. Another limitation for this study was the significant amount of missing data. The records or charts of participants were considered from present and 5 years back into archival records. In most records, essential statistical data such as gender, required for this study were missing; this was even more so for weight change and hyponatremia, which were the variables of interest for statistical analyses. This introduced yet another limitation of missing variable bias. It was challenging, especially for the archival records. This was mainly because the standard inclusion criteria not only required the statistical information of interest to be present, but also the weight measures, sodium levels, and USG values must all have been measured at the same time or within the same period.

Charts or records that did not meet these strict selection criteria only received descriptive statistical analysis. I filtered and cleaned the statistical data to obtain only those charts that strictly met the inclusion for further inferential analysis to deduce accurate and reliable outcomes. According to Wardhani et al. (2019), the implication of using secondary data is having incomplete statistical information; however, using the applicable methods of imputation and missing data analysis can resolve the missing data, calling for positive criticism to the responsible centers to improve compliance. Finally,

due to missing data and data cleaning, the true sample size I used for this study was 48, which was not large enough, despite being very representative.

Recommendations

Adequate health care delivery has never faced more challenges than in the 21st century, and identification of mental disorders and their comorbidities continues to constitute a growing concern in public health (World Health Organization, 2020). Wilson's complexity theory offers a strategic approach to addressing complex behaviors resulting from diseased and complicated biological and social systems that puzzle health care providers (Dunn & Riley-Doucet, 2017). The outcome of this current study strongly supports Wilson's complexity theory. Schizophrenia is a severe, complex mental disorder that could be associated with other severe comorbidities, including polydipsia (Long et al., 2018). Polydipsia in turn, presents complex neurological, biological, and behavioral challenges that complicate the treatment outcome for a person living with schizophrenia; hence, detecting polydipsia is essential (Yamada et al., 2014). The results of this study showed that weight change and hyponatremia, whether individually or in combination, are significantly associated with polydipsia in schizophrenia. I would recommend that further research include a larger population size with complete hospital statistical data, particularly statistical data of interest.

Implications

The outcomes of this research support Wilson's complexity theory. I used weight change and hyponatremia to measure polydipsia. The results were indicative of positive associations of weight change and/or hyponatremia with polydipsia. The public health

perspectives of this analysis are important. The outcomes of this study may offer a framework for positive social change upon which hospital policies, guidelines, and taskforces are championed for quality care regarding severe chronic mental disorders such as schizophrenia. Another implication for positive social change that this study presents is the possibility of a significant reduction in the preventable morbidity and mortality rates of comorbid polydipsia in schizophrenia, due to defective detection of polydipsia. Hence, health care providers may be equipped with easy bedside weight measures and blood sodium levels that inform lifesaving decisions and ensure quality care delivery.

Conclusion

In this research, I furnished insights on the positive association between weight change and/or hyponatremia with polydipsia in individuals with schizophrenia. Prior to this study, the methods of screening for polydipsia in schizophrenia were either too cumbersome or flawed (see Chapter 2's literature review). The association between the independent variables of weight change and/or hyponatremia showed positive results, after controlling for age, ethnicity, duration of illness, and length of stay. The findings of this study may promote social change when applied in health care in polydipsia screening.

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Appendix: Evidence Table

The literature or evidence table below lends an in depth insight into the studies critically appraised to completely research this topic. Although there were so many other peer reviewed and non-peer reviewed articles that researched into polydipsia, these selected ones in the evidence table best met the criteria and focus of this study. The link between polydipsia and chronic schizophrenia was clearly shown, but the complexity of carrying out studies in the vulnerable population presented challenges (Rizvi et al., 2019; Yamada et al., 2014; Kirino et al., 2019). Screening for polydipsia among chronic schizophrenics is essential due to the manifestation of symptoms that further complicate or worsen the morbidity and mortality in this group (Hawken et al., 2009). The method of screening for polydipsia in chronic schizophrenia using genetic markers and polydipsia screening tool, may be effective, but they are cumbersome and lack enough evidence to back them up (Kirino et al., 2019; Reynolds et al., 2004). Urine specific gravity is the most widely used method of screening for polydipsia, but its reliability and accuracy are subjectively questionable (Reynolds et al., 2004). Weight, weight change and hyponatremia are consistent variables in nearly all the selected peer reviewed articles, that have not received enough recognition in the screening of polydipsia in chronic schizophrenia (Poirier et al., 2010)

Author	Method	Source of data	Measure	Findings
Leon, J., D., Tracy, J., McCann, E., & McGrory, A. (2002)	Replication study	588 inpatients with chronic schizophrenia in a psychiatric hospital in the United States of America	IVs: Gender, age, Ethnicity/race, long hospitalization, medication dose – neuroleptics and/or others, smoking, diagnosis of schizophrenia and other medical comorbidities, and weight before DVs: Polydipsia (determined by weight change – before and after, and specific gravity of urine	The association of polydipsia with schizophrenia, smoking and chronicity is consistent and independent from the definition of polydipsia in this study by staff, a biological method or a combination of both
Yamada, K., Shinkai, T., Chen, H., Utsunomiya, K., & Nakamura, J. (2014)	Case-control study	Inpatients' units from 15 psychiatric hospitals in Japan	IVs: Gender (male/female), Age (years old), Age of onset (years old), Duration of illness (years), Current antipsychotic dose (HPD-eq;mg/day), Smoking (yes/no) and COMT Val 108/158 + Met genotype DV: Polydipsia (diagnosed from excessive water intake, hyponatremia and presence of COMT Val 108/158 + Met genotype)	COMT Val 108/158 + Met genotype may confer susceptibility to polydipsia in schizophrenia. This association sustained after controlling for confounders like age, age of onset, antipsychotic dose and smoking status

Author	Method	Source of data	Measure	Findings
Shutty, M., S., & Song, Y. (1997)	Case-control study	15 While male patients diagnosed with chronic schizophrenia in a 450 –bed state psychiatric facility (9 of them has polydipsia and 6 controls)	IV: Polydipsia group – age, age at onset, education level, length of illness, two episodes of hyponatremia, two episodes of diurnal weight gain of at least 5%; Control group – the same variables but without polydipsia DV: Frequency of drinking, amount drunk per bout (ml), rate of drinking, percent of concentrated bouts, total amount drunk (L), frequency of voiding, amount voided per bout (ml), total amount voided (L) and diurnal weight change (Ibs)	Amount drunk per bout for polydipsia patients was nearly three fourths greater than controls, and frequency and concentration of drinking bouts were the most consistent abnormality among polydipsia patients. However, amount drunk per bout and rate of drinking were similar across groups

(*table continues*)

Author	Method	Source of data	Measure	Findings
Torres, I., J., Beenken, B., Keedy, S., Marlow, M., & Goldman, M., B. (2009)	Cross-sectional study	Psychiatric in and outpatient facilities throughout the Chicago area and Psychiatric Clinical Research Center at the University of Illinois at Chicago (all patients have chronic schizophrenia with evidence of hyponatremia – 7, polydipsia – 10, and nonpolydipsia – 9)	IVs: Age, Gender, education years, parental education, age onset, smoking, antipsychotic and other medication, polydipsia (urine specific gravity, weight before and after, hyponatremia) DVs: Neuropsychological impairments measures – global assessment of functioning (GAF), and wide range achievement test (WRT-3)	Patients with schizophrenia and polydipsia, and particularly those with hyponatremia, indicate cognitive deficits compared with patients without water imbalance

(*table continues*)

Author	Method	Source of data	Measure	Findings
Greendyke, R., M., Bernhardt, A., J., Tasbas, & H., E., Lewandowski, K., S. (1998)	Randomized double-blind, placebo-controlled	14 chronically psychotic, institutionalized patients who suffered from psychogenic polydipsia (chronic water abuse). These patients were recruited from a total of 244 psychiatric inpatients via adequate recruitment protocols this kind of study	IVs: Age, duration of psychiatric hospitalization, estimated duration of water abuse, current medications, diagnosis – chronic schizophrenia and others, diurnal weight gain, urine output, serum sodium levels and signs of delirium DVs: Positive response to Clonidine, Enalapril, Clonidine and Enalapril, and to neither drug	In 60% of subjects, there was particular improvement in tests that reflect fluid consumption found with either or both drugs. However, there was no significant improvement in other behaviors

(*table continues*)

Author	Method	Source of data	Measure	Findings
Matsumoto, C., Shinkai, T., De Luca, V., Hwang, R., Hori, H., Lanktree, M., Ohmori, O., Kennedy, J., L., & Nakamura, J. (2005)	Case-control	64 in-patients (45 males, 19 females) with chronic schizophrenia and polydipsia, and 91 in-patients (38 males, 53 females) with chronic schizophrenia without polydipsia as controls. All subjects are Japanese recruited from Psychiatric hospitals within 70km radius	IVs: Age, age of onset of schizophrenia, duration illness, gender, smoking, and current antipsychotic dose in haloperidol equivalents between patients and controls DVs: Polydipsia (weight gain, water intoxication, hyponatremia) and genetic polymorphisms	Polymorphisms in dopamine D2 receptor gene may confer susceptibility to polydipsia in schizophrenia

(*table continues*)

Author	Method	Source of data	Measure	Findings
Reynolds, S., A., Schmid, M., W., & Broome, M., E. (2004)	Cross-sectional survey	5 nurses and 70 psychiatric residents (with chronic schizophrenia and other mental disorders) in a 92-bed nursing home	IVs: 17-item polydipsia screening tool characteristics/symptoms, age, gender, urine specific gravity, weight change (weight gain), smoking, chronic schizophrenia and other comorbid mental disorders, and hyponatremia DVs: validation and reliability Scores and responses from the 17-item polydipsia screening tool (characteristics/symptoms matched against level of 4 levels of risks)	The interrater reliability was 0.84, the average test-retest agreement was 92.4% with agreement ranging from 75% to 100%, and internal consistency of the tool was 0.79. Sensitivity and specificity were 80% and 68% respectively. Another important finding was the validity of the polydipsia screening tool was supported using a medical record history of polydipsia, low serum sodium, and low specific gravity

(*table continues*)

Author	Method	Source of data	Measure	Findings
Rizvi, S., Gold, J., & Khan, A., M. (2019)	Review	Extensive literature search through internal medicine, pain management, and psychiatry using naltrexone, psychogenic polydipsia, schizophrenia, compulsive drinking and opioid receptor as keywords	IVs: Naltrexone, demographic data DVs: Compulsive drinking behavior (measured by weight change and symptoms of psychogenic polydipsia)	The finding of correlation of opioid receptor with compulsive water ingestion in animals, suggests that naltrexone can play a pivotal role in treating psychogenic polydipsia in chronic psychiatric patients
Leon, J., Dadvand, M., Canuso, C., Odom-White, A., Stanilla, J., & Simpson, G., M. (1996)	Cross-sectional study	360 chronically mentally ill inpatients with schizophrenia and other serious psychiatric disorders, in a psychiatric hospital	IVs: Demographic and clinical data – gender, race, diagnosis, and medications DVs: Weight changes	All patients with a history of water intoxication had significantly more extended hospitalizations

(*table continues*)

Author	Method	Source of data	Measure	Findings
Hawken, E., R., Crookall, J., M., Reddick, D., Millson, R., C., Milev, R., & Delva, N. (2008)	Retrospectiv e cohort study	Chart reviews were conducted and follow up data were obtained for 172 inpatients on long stay wards, or who had been on admission wards for longer than 1 year, in Kingston Psychiatric Hospital, Ontario, Canada (48 with chronic schizophrenia had or went on to develop polydipsia, 42 non-polydipsic with schizophrenia were randomly selected as controls)	IVs: Age, gender, age at onset of schizophrenia, age at onset of polydipsia, smoking, marital status, weight gain, urine specific gravity, and water intoxication DVs: number of deaths with polydipsia associated with chronic schizophrenia, causes of death with polydipsia in chronic schizophrenia compared with controls	There is increased mortality when polydipsia is associated with schizophrenia in comparison to that in patients with schizophrenia who do not drink water to excess

(*table continues*)

Author	Method	Source of data	Measure	Findings
Kirino, S., Sakuma, M., Misawa, F., Fujii, Y., Uchida, H., Mimura, M., & Takeuchi, H. (2019)	Systematic Review	Clinical studies and case reports from thorough and detailed literature review and search of MEDLINE, Embase, and PsychINFO via Ovid with keywords such as "drink or water intoxication, or fluid intoxication, or water or fluid concentration, and antipsychotic	IV: Age, age of onset, duration of illness, diagnosis – schizophrenia and other mental illness; polydipsia (hyponatremia, weight before and after, urine specific gravity, water intoxication), antipsychotics (first generation (FGAs) and second generation (SGAs) DV: Responses (before and after treatment of polydipsia) to antipsychotics as shown by Brief Psychiatric Rating Scale Scores/Items on Positive and Negative Symptoms Scale (PANSS)	Antipsychotics with high affinity to dopamine D2 receptors maybe associated with an increased risk of polydipsia while clozapine maybe be effective for treating polydipsia Causal relationship between polydipsia and antipsychotics remains unclear because of the paucity of high-quality studies

(*table continues*)

Author	Method	Source of data	Measure	Findings
Poirier, S., Legris, G., Tremblay, P., Michea, R., Viau-Guay, L., Merette, C., Bouchard, R., Maziade, M., & Roy, M. (2010)	Cohort study	114 subjects from psychiatric inpatients and outpatients, under the age of 50 years, with at least 5 years history of psychiatric follow-up and all having DSM IV diagnosis of schizophrenia	IV: Gender, age, age at onset, medications – neuroleptic, weight before and after, and polydipsia DV: level of functioning as determined by symptom severity – during acute episodes and stabilized stage, lifetime drug use disorder, and lifetime alcohol use disorder	Schizophrenic patients with polydipsia and water intoxication have more severe psychotic symptoms, earlier onset, poorer current adjustment and more frequent prior alcohol use disorder Schizophrenic patients with polydipsia and water intoxication have nonspecific greater severity array of clinical and natural history variables Schizophrenic patients with polydipsia and water intoxication have specific association with alcohol abuse

(*table continues*)

Author	Method	Source of data	Measure	Findings
Parikh, V., Kutlu, M., G., & Gould, T., J. (2016)	Systematic Review	A total of 276 articles searched by two independent reviewers from Medline, Google Scholar and Web of Science, using key words such as smoking, schizophrenia, nicotine, nAChRs, cognition, negative symptoms, positive symptoms, genetics, addiction, neurobiology, and Antipsychotics	IV: Gender, age, age of onset, ethnicity/race, diagnosis – schizophrenia and nicotine addiction, smoking, antipsychotics ID: neurotransmitters – sodium, potassium and calcium, cholinergic nicotinic neurotransmitter	The dysfunction in the central nAChRs represent a common substrate for various symptoms of schizophrenia and comorbid nicotine dependence