Hydration status in older adult patients and the relationship to factors affecting the access and intake of fluid.

Alexandra Smithers

A thesis submitted in partial fulfillment of the requirements for the degree of Masters of Science in Nutrition and Dietetics, Massey University, 2019.

Abstract

Objectives: To assess fluid intake and access among hospitalised patients ≥65 or ≥55 years and to compare total fluid intake with the patient's hydration status as determined by serum osmolality.

Methods: Eligible patients, aged were recruited from Northshore and Waitakere hospitals within the Waitemata DHB in NZ. Socio-demographic characteristics were collected using an electronic questionnaire. The patients' fluid intake was measured using the interactive FIAT, which enabled patients to select any beverage or high fluid food (e.g. jelly, custard, soup) that they had consumed from the hospital, onsite cafeteria, and vending machines. The patients were able to indicate how much they had consumed using a visual representation of the product filled at various volumes for guidance. The patients' access to fluid and potential barriers to them meeting their fluid requirements was assessed using the FAST on an electronic device. Serum osmolality, sodium, potassium, haematocrit and creatinine were determined as indicators of hydration status and collected within 24 hours of the FIAT and FAST.

Results: The study sample (n=54) included 23 (43%) men and 31 (57% women) with a mean age of 82.5±8.10 years. The FIAT identified that the majority of patients did not meet their fluid recommendations (n=46, 90%) and that half (n=27) had a low fluid intake of less than 1.6L/day. The FAST identified that of those patients with low fluid intake 16 (59%) struggled to open fluid containers and 10 (37%) sought assistance with opening. Patients who struggled to open fluids had a higher mean serum osmolality than those who didn't struggle (297±6.88mOsm/kg versus 291±7.80mOsm/kg, P=0.009). Half of the patients were impending dehydration (n=15, 33%) or were dehydrated (n=9, 20%).

Conclusions: Low fluid intake appeared to contribute to dehydration. Early assessment of fluid intake and hydration status is critical to prevent dehydration in older hospitalised patients. It is recommended that health care staff ensure all patients are able to open the provided fluids. Adequate hydration status may aid in the patients recovery, reducing their length of stay and thus the cost of their treatment.

Key words**:** Dehydration, fluid intake, hospitalised, older adults and serum osmolality.

Acknowledgements

First and foremost I would like to thank the patients who took part in this study. Despite being unwell in hospital, you took the time to participate, enabling this project to be possible. I enjoyed listening to each of your stories and was inspired by your character and senses of humour.

Secondly I would like to thank my supervisors and research assistant. Associate Professor Carol Wham, Dr Marilize Richter and Associate Professor Rozanne Kruger, thank you for sharing your extensive knowledge, guidance and supportive words. Danika Pillay, thank you for all your help developing the tools and your assistance with collecting data.

I would also like to thank all my family, friends and classmates for always being there with their unwavering support. Mum, thank you for being my biggest advocate and number one fan. Despite being initially sceptical about me setting out on this journey, you have been there for me 100% in every way possible. Dad, you've always encouraged me to go after my dreams and have helped me to over come any obstacles that get in their way. Thank you for being such a great role model and inspiration.

Mio bellissimo amore, grazie for all the understanding and patience you have showed me. During this process you have always been there to remind me the importance of having fun and to not take myself too seriously.

Table of Contents

List of Tables

List of Abbreviations

ACE	Angiotensin Converting Enzyme
AI	Adequate Intake
ANP	Atrial Natriuretic Peptide
BMI	Body Mass Index
BUN	Blood Urea Nitrogen
DHB	District Health Board
EDTA	Ethylnediaminetetraacetic acid
EFSA	European Food Safety Authority
ESPEN	European Society for Parenteral and Enteral Nutrition
FAST	Fluid Access Scan Tool
FIAT	Fluid Intake Assesment Tool
M-MIT	My Meal Intake Tool
NHANES	National Health and Nutrition Examination Survey
NHMRC	National Health and Medical Research Council
NNR	Nordic Nutrition Recommendations
NNS	National Nutrition Survey
NZ	New Zealand
RAAS	Renin-angiotensin- aldosterone system
SST	Serum Seperating Tube
UK	United Kingdom
US	United States

Chapter 1 – Introduction

Declining birth rates and increased life expectancy have substantially increased the proportion of older adults in populations around the world (Angela Vivanti, Harvey, & Ash, 2010). At the end of 2016, there were 711,200 (15%) people over the age of 65 living in New Zealand (NZ) and this figure is expected to increase by 77% by the end of 2036 (Ministry of Social Development, n.d.).

Dehydration poses a pressing problem within hospitalised older adults due to age related changes, which increase their vulnerability to dehydration. These changes include alterations in total body water, impaired thirst perception, declined renal concentrating ability and vasopressin effectiveness (Begum & Johnson, 2010). Dehydration can adversely impact health status by increasing the risk of urinary tract infections, pressure sores, constipation and pneumonia (Stotts & Hopf, 2003; Warren et al., 1994; Weinberg & Minaker, 1995). If prolonged, dehydration may cause more severe consequences including hypertension, thrombosis, cerebral infarction, mortality, and morbidity (Chan, Knutsen, Blix, Lee, & Fraser, 2002; Manz & Wentz, 2005).

Treatment of complications arising from dehydration may impose significant costs to the health-care system. In the United States (US) $1.36 billion was spent in 1996 to treat hospitalized older adults with dehydration as their primary diagnosis (Kayser-Jones, Schell, Porter, Barbaccia, & Shaw, 1999). This figure is now projected to be greater due to inflation and the increased proportion of older adults (Begum & Johnson, 2010).

The National Health and Medical Research Council (NHMRC) (2006) have set recommendations for fluid intake in NZ. As no single level of water intake would ensure every individual is adequately hydrated, Adequate Intakes (AI) have been established based on the median population intakes in Australia (NHMRC, 2006). The AI's suggest that male older adults require 2.6L/d of fluid from beverages (3.4L/d total fluid) and female older adults require 2.1L/d from beverages (2.8L/d total fluid) (NHMRC, 2006). However, evidence suggests that older adults are not consuming enough fluid to meet these recommendations. A systematic review which included 12 studies of older adults, either free living or in a nursing home, reported the mean intake of drinking water recorded in seven studies ranged from 0.5L-2L/day; total fluid intake (from water and beverages) recorded in five studies ranged 0.6-2.1L/day and total water intake from water, beverages and food ranged from 1.5-3.2L/day (Scherer, Maroto-Sanchez, Palacios, & Gonzalez-Gross, 2016). Age has been found to have an inverse relationship with fluid intake. Observations from the US National Health and Nutrition Examination Survey (NHANES) comparing adults aged 20-50 years and 51-70 years found those over 71 years had the lowest intake of water and other beverages (Drewnowski, Rehm, & Constant, 2013).

Numerous factors may influence the fluid intake of a hospitalised older adult, and contribute to dehydration. Qualitative interviews among hospitalised older adults in a care home in South West England found factors which influenced fluid intake of older adults included a regimented drinks trolley routine, not catering for individual preferences, temperature of the fluid affecting palatability, reduced enjoyment of drinking, lack of awareness of the role food has in fluid intake, insufficient time to finish beverages, frailty affecting independence in drinking and tiredness impeding the consumption of fluids (Godfrey, Cloete, Dymond, & Long, 2012a). Among hospitalised adults in surgical wards in England, median age 72 years, barriers to fluid intake included inability to lift or reach a jug of water and difficulty with pouring a glass of water (Johnstone, Alexander, & Hickey, 2015).

It can be arduous to determine whether an individual is dehydrated due to the ambiguous symptoms. Signs of dehydration may include confusion, dizziness, weakness, thirst, fever, dry skin, sunken eyeballs, poor skin turgor, decreased urine output, and increased heart rate (Pash, Parikh, & Hashemi, 2014). Therefore other methods are required to determine whether patients are dehydrated. Serum osmolality is the gold standard when assessing hydration status as it is able to evaluate dehydration at a single time point without any previous information of the individual (Cheuvront, Kenefick, Charkoudian, & Sawka, 2013; Thomas et al., 2008). The following cut-off values have been used to determine hydration status using serum osmolality: normally hydrated (275 to <295 mOsm/kg), impending dehydration (295–300 mOsm/kg), and current dehydration (>300 mOsm/kg) (Hooper et al., 2015; Thomas et al., 2008). Assessment of serum osmolality among older adults over 65, admitted as emergencies to a large teaching hospital in the United Kingdom (UK), found 37% were identified as dehydrated on admission yet only 8% had dehydration reported clinically by the medical team (El-Sharkawy et al., 2015). This highlights the importance of using a robust measure such as serum osmolality for determining hydration status in hospitalised older adults.

Dehydration is both preventable and reversible (Cole & McCusker, 2002). Health-care outcomes can be improved, and hospital costs reduced, if practitioners routinely monitor those at risk for dehydration and render prompt appropriate care. Currently there is a lack of evidence in Australia and NZ about the relationship between hydration status, fluid intake and the factors affecting fluid intake in hospitalised older adults. Therefore, this study aimed to assess fluid intake and access to fluid among patients ≥65 or ≥55 years admitted to the Assessment Treatment and Rehabilitation wards at Northshore hospital and a medical ward at Waitakere hospital, and to compare the intake of fluid with the patient's hydration status (serum osmolality). This study will provide unique information that may enable early detection of dehydration so that interventions can be initiated to increase fluid intake and prevent dehydration and its complications in older adult patients.

1.1 The aim, objectives and hypothesis

Aim:

To assess fluid intake and access among patients ≥65 years or ≥55 years for Maori or Pacific ethnicities, during their admission to the Assessment Treatment and Rehabilitation wards at Northshore hospital or medical ward at Waitakere hospital, and to compare the total intake of fluid (from water, beverages and food) over 24 hours with the patient's hydration status (serum osmolality).

Objectives:

i. To use an interactive Fluid Intake Assessment Tool (FIAT) to identify the type of fluids consumed and establish the quantity of fluid consumed over a 24-hour period by interviewing the patients after breakfast, lunch and dinner on the same day.
ii. To use a Fluid Access Scan Tool (FAST) to assess the factors affecting fluid intake including the access to fluids, their perceived importance of fluid intake, as well as other potential barriers to meeting their fluid requirements.
iii. To investigate associations between total fluid intake, access and hydration status (as determined by serum osmolality), which will be measured within 24 hours of conducting the FIAT and FAST.

Hypothesis:

As older adults are susceptible to dehydration and access to usual fluid intake may be restricted for patients admitted to a hospital ward, it is predicted that approximately 20% of older *patients will have an inadequate fluid consumption, based on the National Health and Medical Research Council guidelines (2006).

*Older adults in this thesis are defined as those aged 65 years and older or 55 years and older for Maori or Pacific ethnicities. A cut off of 55 years for Maori and Pacific ethnicities is used due to their lower life expectancy compared to the rest of the NZ population (Ministry of Health, 2013, 2014).

1.2 Thesis structure

Four chapters have been used to structure this thesis. Chapter one provided an introduction and insight into the significance of dehydration in older adults in a clinical setting. Chapter two reviews the current literature focusing on various ways to determine whether individuals are dehydrated and what tools have been created to identify those at risk of dehydration. Chapter three is the research study manuscript including the abstract, introduction, methods, results, discussion, conclusion and references. Chapter four addresses whether the aims and objectives were achieved, describes the strengths and limitations of the study and recommendations for further research.

1.3 Research support

Table 1.1: Researchers contributions

Contributors	Contribution
Allie Smithers	Master's student; • Primary researcher/writer • Developed tools • Collected data • Statistical analysis
Associate Professor Carol Wham	Academic supervisor; • Obtained ethics and funding • Research design overview • Thesis guidance and assistance
Dr Marilize Richter	Academic supervisor; • Research design overview • Thesis guidance and assistance including statistical analysis
Associate Professor Rozanne Kruger	Academic supervisor; • Research design overview • Thesis guidance and assistance
Teresa Stanbrook	Point of contact for WHDB; • Logistics of data collection
Danika Pillay	Research assistant; • Developed tools • Collected data

Chapter 2 – Literature Review

2.1 Dehydration

Dehydration is often used as an umbrella term to describe a number of fluid deficit disorders (Mange et al., 1997; Sarhill, Walsh, Nelson, & Davis, 2001; Thomas, Tariq, Makhdomm, Haddad, & Moinuddin, 2003). Extracellular, intracellular and hypertonic volume depletion are all types of dehydration. Volume depletion is the loss of extracellular water accompanied by normal, increased or decreased serum sodium (Sarhill et al., 2001). Intracellular volume depletion is the loss of intracellular volume accompanied by elevated serum sodium (Sarhill et al., 2001). Hypertonic volume depletion occurs when the loss of water is greater than the loss of electrolytes, arising from perspiration, fever or disease (Fried & Palevsky, 1997; O'Brien, Baker-Fulco, Young, & Sawka, 1999; Weinberg et al., 1995).

In NZ there is no one set clinical definition for dehydration. Instead district health boards develop their own guidelines and standards of care to determine whether their patients are dehydrated and what the appropriate interventions may be. Clinical practitioners often use the term dehydration in reference to different types of fluid deficit disorders. As there is no set definition, dehydration will be used throughout this thesis to capture all fluid deficit disorders.

Water, an essential macronutrient (Kleiner, 1999) is the single largest component of the body which makes up the types of body fluids. It enables a number of metabolic processes to occur and accounts for 45-70% of total body weight in an adult, depending on their adiposity (Mahan & Raymond, 2017; NHMRC, 2006). As muscles and viscera are metabolically active cells, they have the highest concentration of water (Mahan & Raymond, 2017). Individuals with greater muscle mass have a greater amount of total body water and those with a smaller muscle mass. Total body water is mainly distributed in the intracellular fluid, the body's largest reservoir of water, and extracellular fluid. (Mueller, Miller, Schwartz, Kovacevich, & McClave, 2012). The movement of water between different compartments of the body is dictated by osmotic forces (Mahan & Raymond, 2017). This is critical to maintain an optimal cellular environment and indefectible body functioning.

Body water is frequently turned over, yet the total amount of body water remains relatively constant under normal conditions due to homeostatic regulation. The water lost through urination, perspiration, faeces and respiration is balanced by the intake of food and beverages. Normally water turnover, excluding perspiration, is approximately 4% of total body weight in adults (NHMRC, 2006). Mechanisms to maintain this homeostasis come from a number of hormones including antidiuretic hormone (vasopressin), aldosterone, angiotensin II, cortisone, norepinephrine and epinephrine (Rhoda, Porter, & Quintini, 2011; Whitmire, 2008). In the presence of low extracellular fluid volume, the kidneys release renin to produce angiotensin II. Angiotensin II has several functions to stimulate vasoconstriction and thirst canters (Whitmire, 2008). An Increased serum osmolality or reduced blood volume stimulates the release of antidiuretic hormone, which signals the kidneys to conserve water by increasing water reabsorption in the renal tubules and creating concentrated urine. However the concentration of urine has a limit at approximately 1400 mOsm/L, once this limit has been reached, the body loses its ability to excrete solutes and thus concentrate urine (Mahan & Raymond, 2017). If the urine cannot be concentrated further homeostasis may become jeopardized.

If alterations to the homeostatic balance are left untreated and the intake of water from various fluids is not increased to compensate, dehydration will result causing a varying degree of severity in consequences. Common causes of dehydration include an increase in physical activity or exposure to heat. An increase in the environmental temperature causes an increase in the vapour pressure gradient, resulting in an increase in water loss from the skin and lungs (Begum & Johnson, 2010; Kavouras, 2002). Unfortunately, dehydration may go undetected for some time due to the ambiguity of the symptoms, such as headache, fatigue, decreased appetite, light headedness, poor skin turgor, decreased urine output, sunken eyes, dry mucous membranes, orthostatic blood pressure changes, and tachycardia (Armstrong, 2005). Even small changes of 2% total body water can adversely affect cell function and cause loss of cognitive function, increase heart rate and decrease exercise performance (Armstrong, 2007; Mahan & Raymond, 2017). A loss of 10% body water may lead to muscle spasms and damage of essential systems and a loss of 20% may result in death (Mahan & Raymond, 2017).

In the clinical setting the homeostatic balance may become compromised by medically specific causes of increased fluid losses and patients consuming an inadequate volume of fluid. Medications such as diuretics, laxatives, anti-depressants, antipsychotics, antibiotics or angiotensin converting enzyme (ACE) inhibitors may increase fluid losses (Westaway et al., 2015). These medications may cause diuresis and electrolyte imbalance, sedation, cognitive impairment, changed thermoregulation, reduced thirst recognition, reduced sweat production, hypotension and reduced cardiac output (Westaway et al., 2015). It is particularly problematic if four or more medications are taken as the cumulative effect poses an even greater risk of deviating from homeostasis (Lavizzo-Mourey, Johnson, & Stolley, 1988; Vivanti, 2007). Other common causes of excessive fluid losses during illness include emesis, diarrhoea, fever, haemorrhage, fistula drainage, burn and wound exudates, gastric and surgical tube drainage and the use some medications (Mahan & Raymond, 2017; Vivanti, 2007). One population group that is particularly vulnerable to developing dehydration is older adults.

2.2 Dehydration in older adults

As older adults have a greater predisposition to becoming dehydrated, more effort is required to maintain their hydration homeostasis. Many physiological changes occur in the body that are an inevitable part of ageing, which increases the risk of developing dehydration. These include a decrease in total body water, renal function, thirst sensations, and the ability to acclimatise to heat (Cohn et al., 1980; Fried & Palevsky, 1997; Mahan & Raymond, 2017; Miller, 1997; Phillips et al., 1993).

A decline in total body water affects hydration homeostasis, as there is reduced fluid reserve. Muscle is the main source of water storage, contributing to approximately 70% of storage, whereas fat stores only contribute approximately 10% to 40% to storage (Rikkert, Melis, & Claassen, 2009). A decline in lean body mass causes total body water to reduce by 10-15%, causing dehydration to become more rapid and frequent (El-Sharkawy, Sahota, Maughan, & Lobo, 2014; Hooper, Bunn, Jimoh, & Fairweather-Tait, 2014). This is problematic as water is vital for the removal of waste products, as well as function of a number of systems including lymphatic, cardiac, gastrointestinal, and urinary tract. Unfortunately, as total body water naturally decreases, these systems become less effective.

From the age of 30 to 80 years renal function reduces by up to 63% (El-Sharkawy et al., 2014), causing an increase in the risk of developing dehydration. With age there is a loss of renal mass due to glomerular sclerosis and glomerular loss (Lindeman, Tobin, & Shock, 1985; Nyengaard & Bendtsen, 1992). These changes impair the ability of the kidney to retain sodium and therefore water, thus predisposing the patient to dehydration, particularly in situations of physiological stress (Hawkins, 2003). Furthermore, vasopressin decreases, disabling the capacity of the kidneys to concentrate urine (Rikkert et al., 2009). This leads to the excretion of large amounts of dilute urine containing a large amount of fluid hence, an even greater risk of older adults developing dehydration.

The thirst response is blunted in older adults causing an increase in the risk of inadequate fluid intake to replace fluid losses (El-Sharkawy et al., 2014). While the mechanism behind why this occurs remains unclear, a few possible mechanisms have been proposed. One is inhibition of the renin-angiotensin-aldosterone system (RAAS) as a result of raised concentrations of atrial natriuretic peptide (ANP) (Burrell, Lambert, & Baylis, 1991). Another more recently proposed mechanism, is that older adults have reduced osmotic and baroreceptor sensitivity, particularly in the left atrium (Hooper, Bunn, Jimoh, & Fairweather-Tait, 2014; Mentes, 2006; Kenney, 2001). This means that the thirst response requires a dramatic increase in osmolality before it is triggered.

Older adults are at particular risk of dehydration when they are unwell or during periods of hot weather as they have a reduced thermoregulatory ability (Schols, Groot, Cammen, & Olde Rikkert, 2009). This reduced thermoregulatory ability can be attributed to a combination of factors, including changes in sweating (Inoue, Shibasaki, Hirata, & Araki, 1998; Kenney & Fowler, 1988), blood flow to the skin (Inoue et al., 1998; Petrofsky et al., 2006) and cardiovascular function (Minson, Wladkowski, Cardell, Pawelczyk, & Kenney, 1998). Changes in sweating are caused by a reduction in total body water, which results in reduced sweat production. This is exacerbated by dehydrated and dry skin, which reduces heat loss and acts to insulate (Warren et al., 1994). Blood flow to the skin changes with age as older adults often experience less active vasodilation upon sweating initiation (Inoue et al., 1998) and therefore less ability to release body heat from the surface of the skin. Central cardiovascular responses to heating are also altered in older adults (Minson et al., 1998). Older adults have a reduced stroke volume contributing to an overall lower cardiac output (Minson et al., 1998), which further contributes to reduced blood flow and an inability to lose heat. An inability to efficiently carry out thermoregulation leads to an internal accumulation of heat, which may lead to dehydration.

The consequences of dehydration in an older adult are particularly detrimental, especially for those that are hospitalised. Older adult patients can deteriorate rapidly and are at a higher risk of iatrogenic and morbid events arising from sodium and water imbalances. These events include confusion and disorientation, infections, constipation, formation of kidney stones, prolapse of the mitral valve, infections of the urinary tract, pneumonia, pressure ulcers, metabolic imbalance, uncontrolled diabetes, gastroenteritis, and even certain forms of cancer (Feinsod et al., 2004; Kositzke, 1990; Maughan, 2003; Xiao & Barber, 2004). Due to the increased risk older adults in hospital have for developing dehydration, it is essential sound procedures are in place to measure and detect dehydration.

2.3 Hydration status

Currently a number of clinical methods determine whether someone is dehydrated. Medical practitioners may look at simple clinical signs and symptoms, short-term changes in body composition, as well as urinary and blood biochemistry including serum osmolality.

Simple clinical signs and symptoms used to determine whether an individual is dehydrated include skin turgor, mouth dryness, and reduced systolic blood pressure. Poor skin turgor may be a useful indication of dehydration when applied to young children (Snyder, Goepp, Katz, & Santosham, 1997; Steiner, Dewalt, Byerley, & Alerts, 2004). However, it demonstrated poor diagnostic performance when applied to older adults, due to loss of skin elasticity with advancing age (McGee, & Simel, 1999). Similarly, dry mucous membranes have not been found to be a reliable indicator of dehydration in older adults due to the impact of mouth breathing, medications, diseases and treatments (Astor, Hanft, & Ciocon, 1999; Greenspan, 1996; Sarhill et al., 2001; Weinberg et al., 1995). Vivanti et al (2008) found that while clinically dehydrated hospitalised older adults have a significant reduction in systolic blood pressure upon standing, the results were confounded by their Body Mass Index (BMI), as subjects with lower BMI's were associated with a greater drop in systolic blood pressure. Due to the lack of evidence supporting the use of these clinical signs and symptoms, the European Society for Parenteral and Enteral Nutrition (ESPEN) guidelines on clinical nutrition and hydration in geriatrics specify that they shall not be used to assess hydration status in older adults (Volkert et al., 2018). In NZ guidelines related to the use of clinical signs and symptoms to assess hydration status in older adults are lacking. However, although they are not a good indicator of hydration status, they are often used in a clinical setting, as they are a cheap, quick and non-invasive.

Short-term changes in body composition have also been used to determine hydration status. A body weight loss of 4% has been widely used to determine dehydrated individuals after physical activity and fluid restriction in athletic and military populations (Armstrong et al., 1998; Casa et al., 1999; Gopinathan, Pichan, & Sharma, 1988; Kovacs, Senden, & Brouns, 1999; O'Brien et al., 1999). However, using body weight in a clinical setting is not an appropriate indicator of hydration status as two time points are required to determine a change in weight, which causes a delay in the identification of dehydration. There are also many other possible reasons for weight change other than dehydration (Cheuvront, Ely, Kenefick, & Sawka, 2010; Shirreffs, 2003; Vivanti et al., 2013). Furthermore, measuring body weight may be a burden to older adult patients especially those with impaired mobility.

2.3.1 Hydration biomarkers

Urinary tests may also be used to determine whether an individual is dehydrated. Such tests include looking at urine output, urine colour, urine specific gravity and urine ketones. Urinary markers can be assessed with minimal training and expense. Although urinary tests appear justified in younger adults, (Cheuvront et al., 2010; Lapides, Bourne, & Maclean, 1965; McKenzie, Muñoz, & Armstrong, 2015; Perrier et al., 2013; Shirreffs, Merson, Fraser, & Archer, 2004) evidence supporting their use in older adults has been weak (Cheuvront et al., 2010; Fortes et al., 2015; Hooper et al., 2014; Mentes, Wakefield, & Culp, 2006; Rowat et al., 2011; Shimizu et al., 2012; Vivanti, Harvey, Ash, & Battistutta, 2008; Wakefield, Mentes, Diggelmann, & Culp, 2002). To the best of my knowledge Hooper et al (2016) carried out the largest study to date looking at the accuracy of urinary analysis to determine dehydration in older adults. They concluded that urine specific gravity tests looked the most promising at diagnosing dehydration however, none of the urinary analysis tests had a receiver operating characteristic curve (ROC_{AUC}) ≥70% or sensitivity and specificity ≥70% at any cut-off for either current dehydration or impending and current dehydration (Hooper, Bunn, Abdelhamid, et al., 2016). Additionally, urinary biochemistry may be difficult to obtain particularly in older adults who are less mobile.

Serum biochemistry may provide a useful insight into the hydration status of an individual over a period of time including creatinine, Blood Urea Nitrogen (BUN)/creatinine ratio, urea, haematocrit, haemoglobin, and electrolytes. With dehydration there is a decrease in the extracellular fluid volume, which causes an increase in the concentration of these serum biochemical markers thus, they may provide an indication of dehydration when elevated above the normal range (Marieb & Hoehn, 2014). However, creatinine, BUN/creatinine ratio and urea are also a measure of renal function (Marieb & Hoehn, 2014). As renal function declines with age, these biochemical markers are not good indicators of hydration status in older adults (Thomas et al., 2008). Furthermore, an elevated haematocrit and haemoglobin may also indicate polycythemia and congestive heart failure (Marieb & Hoehn, 2014). Similarly, serum sodium is elevated in the presence of diabetes insipidus and Cushing's syndrome and potassium is elevated with renal disease, Addison's disease, ketoacidosis and crush injuries (Marieb & Hoehn, 2014). These confounding factors influence these serum biochemical markers, and should not be relied upon for the diagnosis of dehydration or to detect impending dehydration.

Serum osmolality is considered the gold standard when assessing hydration status as it is able to diagnose dehydration at a single time point, without any previous information on the individual (Cheuvront et al., 2013; Thomas et al., 2008). Serum osmolality is a measure of the osmotically active particles per kilogram of blood serum in which the particles are dispersed (Mahan & Raymond, 2017). When we take in too little fluid, the fluid within and around our cells becomes more concentrated, raising the osmolality of the serum and plasma above the normal range (Cheuvront et al., 2010, 2013; Thomas et al., 2008). The following cut-off values have previously been used to determine hydration status using serum osmolality: normally hydrated (275 to <295 mOsm/kg), impending dehydration (295–300 mOsm/kg), and current dehydration (>300 mOsm/kg) (Hooper et al., 2015; Thomas et al., 2008). In order to determine threshold values for serum osmolality, Cheuvront et al (2010) assessed the range of plasma osmolality in hydrated younger adults, then in the same persons who had been dehydrated and determined a threshold of serum or plasma osmolality >300 mOsm/kg for dehydration. This cut-off value concurs with observations from cohort studies assessing effects of raised serum osmolality in older people (Bhalla et al., 2000; El-Sharkawy et al., 2015; Stookey, Purser, Pieper, & Cohen, 2004). However, given the costs and prevalence of dehydration in older people, a cut point of 295 mOsm/L may be more suited as it will identify most older adults with low-intake and should trigger advice and support with fluid intake (Heavens, Kenefick, Caruso, Spitz, & Cheuvront, 2014). All things considered, serum osmolality can be considered the best clinical indicator to assess the hydration status of older adults and is recommended by both the US Institute of medicine (Panel on Dietary Reference Intakes for Electrolytes and Water) and ESPEN to identify dehydration in older adults (Institute of Medicine U.S., 2005; Volkert et al., 2018). Due to the phlebotomy skills required to obtain a blood sample this method may only be suited to the clinical setting.

2.4 Fluid intake

2.4.1 Fluid requirements and guidelines

The minimum amount of fluid one requires is the amount that equals losses and prevents dehydration (Fries et al., 1997). Losses occur via urine, faeces, respiration and evaporation (Sawka, Cheuvront, & Carter, 2005). Excluding perspiration, which is highly variable, the normal turnover of water is approximately 4% of total body weight in adults (NHMRC, 2006). However, men tend to require greater amounts of fluid compared to women as they have a larger lean body mass containing a greater amount of fluid (El-Sharkawy et al., 2014; Rikkert et al., 2009). Majority of fluid loss compensation comes from fluids from beverages (NHMRC, 2013) however, 20-30% of total water intake comes from solid foods (Guelinckx et al., 2016; Kant, Graubard, & Atchison, 2009) and approximately 250 ml is additionally made available from metabolism (NHMRC, 2006). Given the variability in water needs, there is not a single level of water intake that would ensure adequate hydration and optimal health for everyone.

Despite this there are still guidelines in place for the fluid intake of older adults, which are considered adequate to prevent dehydration. The European food safety Authority (EFSA) reviewed the literature and recommended an Adequate Intake (AI) of 2.0 L /day for women and 2.5L/day for men of all ages from a combination of drinking water, beverages and food (EFSA Panel on Dietetic Products, Nutrition, 2010). Assuming 80% of these fluids needs come from drinks (NHMRC, 1999; NHMRC, 2006), women would require 1.6L/day and men would require 2.0L/day (EFSA Panel in Dietetic Products, Nutrition, 2010). Interestingly, the Nordic Nutrition Recommendations (NNR) suggest less fluid intake from beverages due to a greater consumption of fluid from foods. The NNR advise individuals above the age of 14 consume 1-1.5L/day of fluids that are additional to the fluids consumed from food, regardless of their gender (Nordic Council of Ministers, 2012). This is because it is suggested that individuals in Nordic countries also consume foods that contain on average 1-1.5L/day and therefore the total amount of fluids consumed should be approximately 2-3.5L/day (Nordic Council of Ministers, 2012). Slightly lower requirements have been suggested to be appropriate in the US. The institute of medicine wrote a report presenting a series of reference values for nutrient intakes amongst healthy US and Canadian individuals and populations (Institute of Medicine (U.S.)., 2005). The report set general recommendations for women at approximately 2.7L/day of total water, and men approximately 3.7L/day of total water (Institute of Medicine (U.S.)., 2005). Assuming approximately 20% of fluid requirements could be met through food, then women would require approximately 2.2L/day of fluid from beverages and men would require approximately 3L/day of fluid from beverages. Therefore, the recommendations for fluid intake from beverages are greater than those in Europe.

The NHMRC has set recommendations for fluid intake in NZ. As there is no single level of water intake that would ensure every individual was adequately hydrated, an adequate intake (AI) was established based on the median population intakes in Australia (NHMRC, 2006). The guidelines suggest that male older adults require 3.4L/day of total fluid, which equates to

2.6L/d of fluid from beverages and female older adults require 2.8L/day of total fluid which equates to 2.1L/day of fluid from beverages (NHMRC, 2006).

2.4.2 Measuring fluid intake

Currently there is limited research available on the most appropriate method to determine total fluid intake, leading to an inconsistency in methodologies for measuring fluid intake (Popkin, D'Anci, & Rosenberg, 2010). Various methods that are used to measure fluid intake include twenty-four hour recalls, three-day records, seven-day records, frequency questionnaires and other specifically designed tools. However, these methods tend to be designed to mainly capture food intake.

Twenty-four hour recalls are one of the most widely used methods in nutrition epidemiology (Castell, Serra-Majem, & Ribas-Barba, 2015). It is a subjective method where food and beverages consumed twenty four hours prior to the recall are recalled, described and quantified (Castell et al., 2015). As the twenty four hour recall is retrospective, the risk of participants changing their usual intake is minimised (Castell et al., 2015). Another advantage is that they are not very time consuming, reducing participant burden which elevates response rates (Castell et al., 2015). However, the twenty-four hour recall depends on the recent memory of the participants and therefore it is not a recommended method for older adults or young subjects of which have also been found to underestimate intake (Castell et al., 2015). Furthermore one single twenty-four hour recall does not estimate usual intake. Thus, the suitability of this method to determine fluid intake is debatable. To the best of my knowledge, a twenty-four hour recall has not been validated for measuring fluid intake. However, numerous studies have used this method when investigating fluid intake. A systematic review looking at fluid intake was comprised of a variety of methodologies. However, 24-hour recalls were the most frequently used method (29 out of 65 studies, 45%) 22 of which were single 24-hour recalls which the authors of the systematic review noted could not be deemed as appropriate to represent typical individual consumption patterns (Özen, Bibiloni, Pons, & Tur, 2015). However, the majority of these studies investigated fluid intake at a population level (Clifton, Chan, Moss, Miller, & Cobiac, 2011; Csémy, Sovinová, & Procházka, 2012; Drewnowski, Rehm, & Constant, 2013b; Duffey et al., 2012; Garriguet, 2008; Gómez-Martínez et al., 2009; Ribas-Barba et al., 2007; Roche, Jones, Majowicz, McEwen, & Pintar, 2012). Therefore 24-hour recalls may prove useful in large cohorts to indicate mean usual intakes. However, they should be used with caution in smaller samples to assess usual fluid intake in individuals.

Three-day records are not widely used in research to measure fluid intake. They were originally developed to assess individual long-term dietary intake (Burke, 1947). This method requires that subjects complete a three-day food and beverage diary on three consecutive days, recording the amounts consumed in household measures (Burke, 1947). Few studies have used a three-day record to determine fluid intake, despite research suggesting that a three-day record has the comparative advantage over a twenty-four hour recall in young females (Crawford, Obarzanek, Morrison, & Sabry, 1994). It was found that the percentage of absolute errors for the twenty-four hour recall and three-day record ranged from 19-39 and 12-22 respectively. Similarly the proportion of observed foods not reported were 30% and 28% and the proportion of food items not observed were 33% and 10% (Crawford et al., 1994). A more recent study conducted in Iran looked at the correlation between three and seven day records of fluids consumption to determine an appropriate methods for estimating the amount and type of fluids consumed by adults (Karandish, Zilaee, Momeni, & Fathi, 2016). They found that there was no significant difference between three and seven day records regarding the frequency and amount of fluids consumed ($P=0.287$ and $P=0.546$, respectively) and therefore suggested three day records be used in order to determine fluid intake (Karandish et al., 2016).

Seven-day records are a similar method to the three-day records but subjects complete a food and beverage diary for seven days rather than three. It has been suggested that by increasing the number of measurement days, random errors that affect the precision of the method will be reduced (Gibson, 2005). Numerous studies have been found to support this claim. After reviewing different methodologies used to determine adequate fluid intakes for various guidelines around the world, Vergne concluded that a seven-day record was the most appropriate method (Vergne, 2012). Furthermore, Bardosono et al found that when a twenty-four hour recall was compared to a seven-day record, the twenty-four hour recall underestimated total fluid intake by 382 ml (95% CI 299-465). The underestimation was found to increase with increasing fluid intake, resulting in a mean underestimation of 1,265 ml for the highest quartile of total fluid intake (Bardosono et al., 2015). Yet, paper versions of seven-day records have also been found to underestimate fluid intake. Online versions of seven-day records have reported significantly greater fluid intake than paper versions (1,348 ± 36 vs. 1,219 ± 34 ml/day, respectively). The authors hypothesised that these results were due to the online version capturing more drinking events outside of meals (Monnerie et al., 2015). Interestingly, more than 75% of the 246 participants reported that they preferred using the online version (Monnerie et al., 2015).

Several beverage frequency questionnaires have being developed in the last sixteen years as a way to determine habitual fluid intake (Marshall, Eichenberger Gilmore, Broffitt, Levy, & Stumbo, 2003; Marshall, Eichenberger Gilmore, Broffitt, Stumbo, & Levy, 2008; Nelson & Lytle, 2009). However, these questionnaires were designed to measure beverage intake in children and adolescents, and most do not exclusively measure beverage intake. Thus, in 2010 Hedrick et al developed the BEVQ-19, a quantitative 19 item questionnaire that measures the frequency of beverage items as well as the amounts consumed (Hedrick, Comber, Estabrooks, Savla, & Davy, 2010). The BEVQ-19 estimates habitual mean daily intake across 19 different beverage categories which include water, soft drinks, juice, milk, alcohol, tea, coffee and energy drinks (Hedrick et al., 2010). The BEVQ-19 was revised in 2012 to make it more user friendly and thus, the BEVQ-15, was developed, which possesses the ability to provide accurate and reliable information comparable to that of the full-length version (Hedrick et al., 2012). Furthermore, the Water Balance Questionnaire was developed in 2012, which not only consider fluid intake but also takes into account fluid output to evaluate water balance. The questionnaire includes a series of questions regarding the profile of the individual, consumption of food, beverage intake, physical activity, sweating, urination, defecation and trends on fluid intake (Malisova, Bountziouka, Panagiotakos, Zampelas, & Kapsokefalou, 2012). The validity of the questionnaire was assessed using a combination of hydration indices including urine volume, colour and osmolality (Malisova et al., 2012).

Recently more novel tools have been developed as a way to measure fluid intake. The My Meal Intake Tool (M-MIT) was developed to determine the food and fluid intake of patients at one particular mealtime in a hospital setting. The tool prompts patients to note down the drinks that came on their meal tray and to indicate with an 'X' whether they had none, 25%, 50%, 75% or all of it. The tool was tested with 120 patients over the age of 65 across four Canadian hospitals completed the M-MIT and a dietitian at each hospital visually estimated food and fluid waste. Associations between the dietitian observations and the M-MIT were statistically significant (P=<0.001) and absolute agreement between dietitian and patient estimations for fluid intake was 76.5% (McCullough & Keller, 2018). Tools are also being developed to make use of the technology that is now easily available to subjects. A smart water bottle (Hidrate Spark™, Minneapolis, MN) was developed as a non-invasive fluid intake monitoring system, but it is yet to be validated in a clinical setting (Borofsky, Dauw, York, Terry, & Lingeman, 2018). The bottle contains an internal sensor that detects changes in water level to calculate the volume that has been drunk, the data is then sent wirelessly to the user's smartphone via an application. This enables subjects to track daily fluid intake in real time (Borofsky et al., 2018). Upon pilot testing the new novel tool, researchers found that twenty four hour fluid intake measurements and the smart bottle were accurate within 3% of each other (Borofsky et al., 2018). This suggests that the smart water bottle may be a useful future research tool for investigating fluid intake.

2.4.3 Factors affecting fluid intake in a clinical setting

To help ensure adequate fluid intake and hydration in older adults, it is important to determine what factors are affecting their access to and consumption of fluids. Potential factors that may play a role in influencing how much fluid an older adult consumes include fear of incontinence, reduced physical strength and mobility, preferences, support and environmental conditions.

Often older adults will reduce their fluid intake as a way to control potential incontinence issues or the need for assistance to go to the toilet (Godfrey et al., 2012). While incontinence issues may not have been found to be a risk factor for dehydration, they have been found to be a risk factor for significantly lower fluid intake compared to continent subjects (Armstrong-Esther, Browne, Armstrong-Esther, & Sander, 1996; Lavizzo-Mourey et al., 1988). Interestingly, reducing fluid intake may actually make incontinence issues worse. As the urine becomes concentrated there is an increase in the likelihood of episodes of urinary incontinence (Williams & Pannill, 1982). Therefore, fluid restriction should be discouraged unless medically indicated (Hoffman, 1991).

Reduced physical strength and mobility is another factor, which may influence fluid intake in older adults. Research has shown that often the food and beverages provided in a clinical setting are challenging for older adults to open (Mathiowetz et al., 1985; Voorbij & Steenbekkers, 2002; Yoxall et al., 2006). Bell et al (2013) found that patients had difficulty opening milk and juices (52%), cereal (49%), condiments (46%), tetra packs (40%) and water bottles (40%). These difficulties were attributed to 'fiddly' packaging, hand strength and vision. However, paralysis, fractures and arthritis may also restrict a patient's ability to open food and beverage packaging (Bell et al., 2013; Schenker, 2003). Furthermore, food and beverages may be left out of reach for older adults, may not be offered, or may be too heavy for them to pick up and use such as water jugs (Godfrey et al., 2012a; Hooper et al., 2014b).

Patient preferences to the timing and types of drinks available also impact the amount of fluid older adults consume in a clinical setting. Some patients may prefer hot drinks while some may prefer chilled drinks (Godfrey et al., 2012a). In a residential setting it has been recommended that hot drinks are made available for individuals for people to help themselves (Hodgkinson, Evans, & Wood, 2003). Perhaps in a clinical setting it is more appropriate for hot drinks to be offered regularly during the day including between meals. However, then the timing of the drinks trolley may still not suit the patients. It has been found that sometimes the drinks trolley comes too late in the morning after patients who wake up early have already been awake for a couple of hours or it comes too early in the evening when some patients will still be awake for a few more hours (Godfrey et al., 2012a). Furthermore, when different people are responsible for the drinks trolley each shift it leads to inconsistencies in the patients experience (Godfrey et al., 2012a). Offering a variety of drinks more frequently throughout the day, to accommodate patient preferences would likely increase patient fluid intake.

Systems of support and care can also affect fluid intake and hydration in older adults. Staffing numbers and the abilities of staff to assist effectively with drinking and toileting have previously been identified as major issues affecting fluid intake (Kayser-Jones et al., 1999; Simmons, Osterweil, & Schnelle, 2001). Prompting residents to finish drinks increases drinking in cognitively impaired older adults, but for older people with minimal cognitive impairment, prompting may have a negative effect on drinking (Simmons, Alessi, & Schnelle, 2001). Therefore, the ability of staff to make subtle judgements is important. Staff training may also be crucial to ensure staff are aware of the importance of hydration in older people, are knowledgeable about how to monitor fluid intake or hydration status, and are able and willing provide appropriate assistance (Kayser-Jones et al., 1999; Ullrich & McCutcheon, 2008).

Social and environmental conditions can be crucial in supporting eating and drinking for older adults. People tend to eat and drink together whenever they meet, chat, bond, or share a hobby or experiences (Philpin, Merrell, Warring, Gregory, & Hobby, 2011). While social contact is an important trigger for drinking, social isolation is common in older people, especially those who are hospitalised. It has been suggested that in a residential setting smaller dining areas with a more “homely” feel are set up so residents can eat and drink in small friendly supportive groups (Dickinson, Welch, & Ager, 2008; Godfrey et al., 2012a; Kenkmann, Price, Bolton, & Hooper, 2010). This may prove challenging to initiate in a hospital setting as wards do not have suitable dining areas and nursing and/or health care assistants may not be available to transport patients safely to and from a dining area. Nevertheless s social contact with other patients may reap great benefits, as hospitalised older adults are often isolated and confined.

2.5 Summary

Dehydration may pose a pressing problem for hospitalised older adults who may be vulnerable due to age related changes, including a decrease in: total body water, renal function, thirst sensation, and the ability to acclimatise to heat (Cohn et al., 1980; Fried & Palevsky, 1997; Mahan & Raymond, 2017; Miller, 1997; Phillips et al., 1993). Dehydration can adversely impact health status and if prolonged may cause severe consequences including mortality and morbidity (Chan et al., 2002; Manz & Wentz, 2005).

Determination of dehydration status can be challenging in the presence of ambiguous symptoms. Serum osmolality is considered the gold standard when assessing hydration status as it is able to evaluate dehydration at a single time point and without any previous information of the individual (Cheuvront et al., 2013; Thomas et al., 2008). Assessment of serum osmolality among older adults over 65 years, admitted to the emergency department of a large teaching hospital in the UK, found 37% were identified as dehydrated on admission yet only 8% had dehydration reported clinically by the medical team (El-Sharkawy et al., 2015). This highlights the importance of using a robust measure such as serum osmolality for determining hydration status in hospitalised older adults.

The NHMRC recommendations for fluid intake in NZ suggest 2.6L/d of fluid from beverages (3.4L/d total fluid) for men and 1L/d from beverages (2.8L/d total fluid) for women (NHMRC, 2006). Yet, evidence suggests that older adults are not consuming enough fluid to meet these recommendations (Scherer et al., 2016). This may be attributed to a number of factors, which affect fluid intake, in hospitalised older adults such as a fear of incontinence, reduced physical strength and mobility, patient preferences, staff assistance and social isolation (Bell et al., 2013; Godfrey, Cloete, Dymond, & Long, 2012b; Simmons, Alessi, et al., 2001).

Dehydration is both preventable and reversible (Cole & McCusker, 2002). Health-care outcomes can be improved, and hospital costs reduced, if practitioners routinely monitor those at risk for dehydration and render prompt appropriate care. To date the relationship between hydration status, fluid intake and the factors affecting fluid intake in hospitalised older adults has not been investigated in New Zealand. Therefore, this study aimed to assess fluid intake using a FIAT (Appendix A.5), barriers to access using a FAST (Appendix A.4) and to compare the intake of fluid with hydration status using serum osmolality among older patients.

Chapter 3 – Research Study Manuscript

This manuscript is formatted for submission to the Australasian Journal on Ageing (Author guidelines in Appendix C). Additional methodological details are provided in Appendix A and results in Appendix B. The referencing style for the research manuscript has been changed from the guidelines to be consistent between thesis chapters and to accommodate the ease of reading.

Objectives: To assess fluid intake and access among older hospitalised patients and to compare total fluid intake with the patient's hydration status as determined by serum osmolality.

Methods: Eligible patients completed an interactive FIAT, FAST, and questionnaire to assess demographic characteristics, factors affecting fluid intake and total fluid intake volume. Serum osmolality and biomarkers were determined as indicators of hydration status.

Results: Of 54 patients (mean age 82.5±8.10 years), half (n=27) had a low fluid intake <1.6L/day. Of those with a low fluid intake 16 (59%) struggled to open fluid containers and 10 (37%) sought assistance with opening. Patients who struggled to open fluids had a higher mean serum osmolality than those who didn't struggle (297±6.88mOsm/kg versus 291±7.80mOsm/kg, P=0.009).

Conclusions: Low fluid intake appeared to contribute to dehydration. Early assessment of fluid intake and hydration status is critical to prevent dehydration in older hospitalised patients.

Key words: Dehydration, fluid intake, older adults and serum osmolality

3.1 Introduction

Dehydration poses a pressing problem to hospitalised older adults due to age related changes in total body water, impaired thirst perception, declined renal concentrating ability and vasopressin effectiveness (Begum & Johnson, 2010). Dehydration can adversely impact health status by increasing the risk of urinary tract infections, pressure sores, constipation and pneumonia (Stotts & Hopf, 2003; Warren et al., 1994; Weinberg, & Minaker, 1995). If prolonged, dehydration may cause more severe consequences including hypertension, thrombosis, cerebral infarction, mortality, and morbidity (Chan et al., 2002; Manz & Wentz, 2005). Hospitalised patients who are dehydrated may have worse clinical outcomes and stay in hospital on average 4.7 days longer than patients who are hydrated (Pash et al., 2014).

Treatment of complications arising from dehydration may impose significant costs to the health-care system. In the United States $1.36 billion was spent in 1996 to treat hospitalised older adults with dehydration as their primary diagnosis (Kayser-Jones et al., 1999). This cost is projected to be greater due to inflation and the increased proportion of older adults in the population (Begum & Johnson, 2010).

Numerous factors may influence the fluid intake of hospitalised older adults, and subsequently contribute to dehydration. Godfrey and co-workers (2012) used qualitative interviews to investigate dehydration care of hospitalised older adults in a care home in South West England. Factors found to influence fluid intake included a regimented drinks trolley routine, not catering for individual preferences, temperature of the fluid affecting palatability, reduced enjoyment of drinking by participants, lack of awareness by the older adults in the role food has in fluid intake, insufficient time to finish beverages, frailty affecting independence in drinking, and tiredness impeding the consumption of fluids (Godfrey et al., 2012). Among hospitalised adults in surgical wards in England, median age 72 years, barriers to fluid intake included inability to lift or reach a jug of water and difficulty with pouring a glass of water (Johnstone et al., 2015).

Dehydration is both preventable and reversible (Cole & McCusker, 2002). Health-care outcomes can be improved, and hospital costs reduced, if practitioners routinely monitor those at risk for dehydration and render prompt appropriate care. Currently there is a lack of evidence in Australia and NZ about the hydration status in hospitalised older adults. Therefore, this study aimed to assess the factors affecting fluid intake and total fluid intake volume for older patients admitted to the Assessment Treatment and Rehabilitation wards at

Northshore hospital and a medical ward at Waitakere hospital in Auckland NZ, and to compare the intake of fluid with the patient's hydration status.

3.2 Methods

A dual setting cross-sectional study was undertaken within the Waitemata District Health Board (DHB) of Auckland. Waitemata is made up of defined geographical regions including North Shore City and Waitakere City and provides services to the largest DHB population in NZ (Waitemata District Health Board, n.d.).

Ethical approval was obtained from the Health and Disability Ethics Committee: 18/NTA/45 and the study was registered with the Research and Knowledge centre at Waitemata District Health Board # RM13993.

3.2.1 Eligibility and recruitment

Patients aged ≥65 years or ≥55 years for Maori and Pacific ethnicities who have lower life expectancy compared to the rest of the NZ population (Ministry of Health, 2013, 2014) who were able to understand and give consent for the study, were eligible to participate. Exclusion criteria included patients who had a restricted or controlled fluid intake (IV fluids) in the past 24 hours, required an interpreter, participated in another study, used diuretics or anti-psychotic medication, required thickened fluids, had a diagnosed cognitive disorder and /or a stoma. Patients were screened to ensure there had been no changes to their medical condition or cognition and they were not planned for discharge in the next two days. Eligible patients were then provided with an information sheet and written consent was obtained before the interviews were conducted. A standard interview protocol was used by the two research assistants to ensure consistency in data collection.

3.2.2 Measures

Study measures were obtained by conducting a structured face-to-face interview, using an electronic questionnaire format (Appendix A.3). Socio-demographic characteristics including age, gender, ethnicity, marital status, education and income were recorded. Education was ascertained by attendance at primary, secondary and tertiary education. Income was assessed as pension only or pension plus other source of income. Whether the participants required help for daily tasks or received a regular subsidised support service was determined Dentition was recorded as either has full dentures, partial dentures or own teeth. Prescribed medications were recorded from the patient's clinical notes at the time of data collection and upon patient discharge.

3.2.3 Fluid intake

The patient's fluid intake was measured using an interactive electronic tool -the FIAT (Appendix A.5). The FIAT consisted of a visual representation of the drinks available on the New Zealand national Compass hospital menu including water, coffee, tea, milo, milk, pinto juice, kiwi crush and dietitian prescribed supplement drinks as well as the patient drinks and water. Food with a high fluid content (such as yoghurt, custard, jelly, ice cream, soup and milky puddings) from the hospital menu were also included in the tool as well as beverages that were not provided by the hospital but available in vending machines and the cafeteria (soft drinks, sports drinks, fruit flavoured drinks and bottled water). Once the type of fluid was selected the FIAT displayed a visual representation of fluid measures (including jugs, mugs, cups and original product packaging) in increments of one fifth of the total item volume.

The fluid intake assessment was undertaken after meals (breakfast, lunch and dinner) and coincided with the 24-hour period when blood was drawn to measure serum osmolality. Patients were prompted to ensure the fluids consumed before, during and after meals were recorded.

3.2.4 Fluid access

The patient's access to fluid items was assessed using the FAST on an electronic device (Appendix A.4). The FAST consisted of 27 questionnaire items, designed to assess the patient's access to fluid, their perception regarding the importance of fluid, as well as other potential barriers in meeting their fluid requirements. A closed question format was used in order to filter out irrelevant topics.

3.2.5 Biochemistry

A serum osmolality test was collected in addition to the routinely collected potassium, sodium, creatinine and haematocrit. The medical team carried out the venepuncture on the patient's medial cubital vein. The potassium, sodium and creatinine samples were collected in an 8.5ml Serum Seperating Tube (SST) vacutainer and the haematocrit sample was collected in a 6ml ethylenediaminetetraacetic acid (EDTA) vacutainer. Samples were sent to the hospital laboratory for analysis.

The potassium and sodium samples were analysed using a Beckman Coulter Unicel DxC800 Synchron Clinical System, which uses ion selective electrodes to determine the concentration of sodium and potassium in solution. The creatinine samples were analysed using a Beckman

Synchron LX20 using kinetic alkaline picrate. The haematocrit samples were analysed using a Beckman Coulter MAXM using the Beckman Coulter method of counting and sizing (Beckman Coulter Life Sciences, n.d.).

3.2.6 Statistical analysis

The sample was stratified into hydration groups and fluid intake groups. The following serum osmolality cut points were used for the hydration groups: <295mOsm/kg for hydrated patients, 295-299mOsm/kg for patients impending dehydration and ≥300mOsm/kg for dehydrated patients. The following volumes were used for the fluid intake groups: <1.6L/day for low fluid intake and >1.6L/day for potentially sufficient fluid intake.

IBM SPSS statistic software, version 24.0 (SPSS Inc., Chicago IL, USA) was used to carry out the statistical analysis. For descriptive purposes, frequencies were calculated for the demographic, physical health and characteristics, hydration status and fluid intake data. An ANOVA test was used to determine the mean and standard deviation for the hydration groups and fluid intake. Chi square tests were used to compare fluid intake and FAST data, medications and whether patients were meeting their fluid requirements. Independent t-tests were carried out on serum osmolality, creatinine, haematocrit, sodium, potassium, FAST data and medications. P-values were deemed significant if ≤0.05.

3.3 Results

A total of 54 patients were in the study (23 men; 31 women) mean±SD age 82.5±8.10 years. A serum osmolality was available for 45 patientsand fluid intake data (FIAT) was collected for 51 patients. Missing data occurred due to patient discharges or unavailable blood tests. The majority of patients (n=47, 87%) identified as NZ European (Table 1). Approximately one third (n= 19, 35%) lived alone and most (n= 51, 95%) received a secondary or tertiary education. Three quarters of the patients (n= 40, 74%) had partial or full dentures. Half of the patients were dehydrated (n=9, 20%) or had impending dehydration (n=15, 33%) and most (n= 46, 90%) did not meet the fluid requirements based on the NHMRC (2006) recomme ndations. Few (n=5, 9%) patients consumed fluids not provided by the hospital. Both men and women consumed most fluids in the morning (0.75L and 0.64L/day respectively). The main contributor to fluid intake for men and women was hot beverages (mean intake 0.7L/day), whereas women consumed the least amount of water (mean intake 0.4L/day) (Table 3.1).

Table 3.1: Participant characteristics, hydration status and fluid intake.

Characteristics		**Total (n%)**
Demographic		54
Gender	Men	23 (42.6)
	Women	31 (57.4)
Ethnicity	NZ European	47 (87)
	Other	7 (13)
Marital Status	Married/partnered	23 (42.6)
	Divorced/separated	8 (14.8)
	Widowed	21 (38.9)
	Other	2 (3.7)
Living situation	Living with others	35 (64.8)
	Living alone	19 (35.2)
Highest level of education	Primary or none	3 (5.6)
	Secondary	38 (70.4)
	Tertiary/trade	13 (24.1)
Income	Pension only	23 (42.6)
	Other	31 (57.4)
Physical and health		***54***
Requires help for daily tasks	Yes	29 (53.7)
	No	25 (46.3)
Receives regular subsidised support services	Yes	20 (37)
	No	34 (63)
Dentures	Yes	40 (74)
	No	14 (26)
Hydration status		***45***
Hydrated	Yes	21 (46.7)
	No	24 (53.3)
Impending dehydration	Yes	15 (33.3)
	No	30 (66.7)
Dehydrated	Yes	9 (20)
	No	36 (80)
Fluid intake		*51*
Meets fluid requirements	Yes	5 (9.8)
	No	46 (90.2)
Consumption of fluid not provided by the hospital	Yes	5 (9.8)
	No	46 (90.2)
Total fluid intake†	Men	1.843L/day (0.623-3.612L/day)
	Women	1.573L/day (0.590-2.812L/day)
Morning fluid intake†	Men	0.747L/day (0.261-1.645L/day)
	Women	0.640L/day (0.260-1.163L/day)
Midday fluid intake†	Men	0.493L/day (0.176-0.910L/day)
	Women	0.562L/day (0.140-1.140L/day)
Evening fluid intake†	Men	0.505L/day (0.116-1010L/day)
	Women	0.489L/day (0.160-1600L/day)

Characteristics		Total (n%)
Water intake†	Men	0.650L/day (0.108-2.450L/day)
	Women	0.374L/day (0-0.966L/day)
Hot drink intake†	Men	0.659L/day (0-1.560L/day)
	Women	0.668L/day (0.080-1.320L/day)
Other fluid intake†	Men	0.533L/day (0.180-0.965L/day)
	Women	0.531L/day (0-1.235L/day)

† Data presented as mean (range).

Half of the patients consumed less than 1.6L of fluid per day (Table 3.2). Among the patients (n=27, 50%) with a low fluid intake (<1.6L/day), (n=15) 56% perceived the intake of fluid to be unimportant to somewhat important, when rating it on a scale on one to five. Similarly, of those with a low fluid intake (n=16) 59% struggled to open the lids of the fluids provided by the hospital, yet only (n=10) 37% sought assistance with opening from staff or visitors. A third (n=9) 33% of patients with low fluid intake were prescribed ten or more medications before their hospital admission, which increased to (n= 11) 41% upon discharge. Of those with low fluid intake, (n=10) 37% were discharged with newly prescribed anti-hypertensive medications and (n=7) 26% with newly prescribed laxative medications.

Table 3.2: Factors affecting patient access to fluid and medication use by low and adequate fluid intake.

		Total (n%)	Fluid intake <1.6L n (%)	Fluid intake ≥1.6L n (%)	P-Value
Participants (n%)		54	27	27	
Has water jug	Yes	53 (98.1)	26 (96.3)	27 (100)	0.313
	No	1 (1.9)	1 (3.7)	0 (0)	
Can pour water	Yes	51 (94.4)	26 (96.3)	25 (92.6)	0.552
	No	3 (5.6)	1 (3.7)	2 (7.4)	
Unfinished drinks removed	Yes	1 (1.9)	0 (0)	1 (3.7)	0.313
	No	53 (98.1)	27 (100)	26 (96.3)	
Meal time position	Sit upright	52 (96.3)	25 (92.6)	27 (100)	0.150
	Lie back	2 (3.7)	2 (7.4)	0 (0)	
Interrupted during meal times	Yes	23 (42.6)	14 (51.9)	9 (33.3)	0.169
	No	31 (57.4)	13 (48.1)	18 (66.7)	
Able to finish meal when interrupted	Yes	53 (98.1)	27 (100)	26 (96.3)	0.313
	No	1 (1.9)	0 (0)	1 (3.7)	
Fluid consumption encouraged	Yes	42 (77.8)	20 (74.0)	22 (81.5)	0.513
	No	12 (22.2)	7 (26.0)	5 (18.5)	
Perceived importance of fluid intake	Not important to somewhat important	23 (42.6)	15 (55.6)	8 (29.6)	0.054
	Important to very important	31 (57.4)	12 (44.4)	19 (70.4)	
Requires assistance when drinking	Yes (straws)	4 (7.4)	1 (3.7)	3 (11.1)	0.299
	No	50 (92.6)	26 (96.3)	24 (88.9)	

		Total (n%)	Fluid intake <1.6L n (%)	Fluid intake ≥1.6L n (%)	P-Value
Struggles to open hospital fluids lids	Yes	26 (48.1)	16 (59.3)	10 (37.0)	0.102
	No	28 (51.9)	11 (40.7)	17 (63.0)	
Seeks assistance to open beverages	**Yes**	**17 (31.5)**	**10 (37.0)**	**7 (25.9)**	**0.184**
	No	**37 (68.5)**	**17 (63.0)**	**20 (74.1)**	
Consumes beverages that are not provided by the hospital	Yes	15 (27.8)	7 (25.9)	8 (29.6)	0.761
	No	39 (72.2)	20 (74.1)	19 (70.4)	
Constipated	Yes	19 (35.2)	9 (33.3)	10 (37.0)	0.776
	No	35 (64.8)	18 (66.7)	17 (63.0)	
Vomiting last 3 days	Yes	5 (9.3)	1 (3.7)	4 (14.8)	0.159
	No	49 (90.7)	26 (96.3)	23 (85.2)	
Diarrhoea last 3 days	Yes	7 (13.0)	5 (18.5)	2 (7.4)	0.224
	No	47 (87.0)	22 (81.5)	25 (92.6)	
Reduced fluid intake to manage diarrhoea	Yes	2 (3.7)	2 (7.4)	0 (0)	0.150
	No	52 (96.3)	25 (92.6)	27 (100)	
Difficulty controlling bladder	Yes	23 (42.6)	13 (48.1)	10 (37.0)	0.409
	No	31 (57.4)	14 (51.9)	17 (63.0)	
Reduced fluid intake to manage bladder control	Yes	1 (1.9)	0 (0)	1 (3.7)	0.313
	No	53 (98.1)	27 (100)	26 (96.3)	
Only drinks when thirsty	Yes	1 (1.9)	0 (0)	1 (3.7)	0.313
	No	53 (98.1)	27 (100)	26 (96.3)	
Regular medications (n)	5 or less	13 (24.1)	8 (29.6)	5 (18.5)	
	6-10	26 (48.1)	10 (37.1)	16 (59.3)	0.167
	10 or more	15 (27.8)	9 (33.3)	6 (22.2)	
d/c medications (n)	5 or less	12 (22.2)	6 (22.2)	6 (22.2)	
	6-10	22 (40.7)	10 (37.1)	12 (44.4)	0.920
	10 or more	20 (37.1)	11(40.7)	9 (33.4)	
d/c with new antihypertensive medications	Yes	16 (29.6)	10 (37.0)	6 (22.2)	0.491
	No	38 (70.4)	17 (63.0)	21 (77.8)	
d/c with new laxative medications	Yes	14 (25.9)	7 (25.9)	7 (25.9)	1.00
	No	40 (74.1)	20 (74.1)	20 (74.1)	

d/c: discharged.
Pearson's chi-square used to test for significance.
Low fluid intake <1.6L/day; adequate fluid intake ≥1.6L/day

Patients that were hydrated (<295mOsm/kg) had a mean±SD serum osmolality of 286±5.19mOsm/kg, a mean±SD fluid intake of 1.74±0.41 L/day and a mean±SD age of 81.2±8.55 years. Those that were impending dehydration had a mean±SD serum osmolality of 297±1.19mOsm/kg, fluid intake (1.54±0.37L/day) and were a mean±SD age of 82.9±7.08 years. The patients who were dehydrated had a mean±SD serum osmolality of 303±3.84mOsm/kg, a mean±SD fluid intake of 1.43± 0.30 L/day and were a mean±SD age of 84.9±8.87 years (Table 3.3).

Table 3.3: Biochemical markers for hydration, age and total fluid consumption compared to different hydration groups.

	Total (n) Mean ±Std	**Hydrated (<295mOsm/Kg) Mean ±Std**	**Impending dehydrated (295– 299mOsm/Kg) Mean ±Std**	**Dehydrated (≥300mOsm/Kg) Mean ± Std**	**P-value**
N (%)	45 (100)	21 (46.67)	15 (33.33)	9 (20)	
Age (years)	82.51±8.10	81.19±8.55	82.93±7.08	84.89±8.87	0.513
Serum Osmolality (mOsm/Kg)	293.31±7.91	286.48±5.19	296.87±1.19	303.33±3.84	**<0.001***
Creatinine (umol/L)†	77.73±0.34	71.91±0.36	79.16±0.25	90.57±0.36	0.223
Haematocrit	0.37±0.06	0.37±0.05	0.36±0.06	0.38±0.06	0.746
Potassium (mmol/L)	4.09±0.36	4.11±0.31	4.07±0.37	4.11±0.50	0.943
Sodium (mmol/L)	138.53±2.89	137.19±2.73	139±2.30	140.89±2.57	**0.003***
Total fluid volume (ml)†	1604.071±0.38	1743.24±0.41	1536.56±0.37	1425.53±0.30	0.371

Anova analysis was used to test for significance.
*Significant difference between groups P≤0.05.
†Geometric mean was used.
Reference ranges: Total fluid volume for men 2.6L/day and for women 2.1L/day as per the NHMRC guidelines (NHMRC, 2006), creatinine 45-90umol/L, haematocrit 0.35-0.46, potassium 3.5-5.2mmol/L and sodium 135-145mmol/L as per Waitemata DHB protocol.

Patients who were able to pour themselves a glass of water using a hospital water jug, had a significantly higher serum osmolality compared to those who were unable to pour water (294±7.73mOsm/kg versus 284±3.61mOsm/kg, P=0.033). Patients who struggled to open the lids on fluid items also had a significantly higher mean serum osmolality, outside of the normal range, compared to those who didn't struggle (297±6.88mOsm/kg versus 291±7.80mOsm/kg, P=0.009). Patients who reported consuming less fluid to manage loose bowels had a significantly higher creatinine and a higher serum osmolality, both outside of the normal range, compared to those who didn't restrict fluid intake (122±0.53umol/L versus 77.2±0.30umol/L, P=0.04 and 300±9.90mOsm/kg versus 294±7.81mOsm/kg, P=0.225). Similarly, patients who had experienced vomiting within three days of data collection had a significantly higher creatinine and a greater haematocrit, both outside of the normal range, compared to those who hadn't vomited (104±0.39umol/L versus 76.3±0.30umol/L, P=0.04 and 0.342±0.04 versus 0.369±0.06, P=0.303). Patients who had difficulty swallowing had a haematocrit above the reference range versus those who had no difficulty who had a haematocrit within the normal range (0.317±0.04 versus 0.342±0.04, P=0.106) (Table 3.4).

Table 3.4: Risk factors for dehydration by serum osmolality and selected biomarkers.

	Serum Osmolality (mOsm/Kg)	**Haematocrit**	**Creatinine (umol/L) †**	**Potassium (mol/L)**	**Sodium (mol/L)**
Able to pour water					
Yes	293.98±7.73	0.364±0.05	79.68±0.31	4.065±0.36	138.43±2.85
No	284.00±3.61	0.410±0.07	62.55±0.43	4.400±0.44	135.33±4.51
P-Value	**0.033***	0.249	0.204	0.127	0.082
Struggled to open hospital fluid lid					
Yes	296.52±6.88‡	0.360±0.05	80.40±0.38	4.112±0.42	138.28±3.34
No	290.50±7.80	0.372±0.06	76.78±0.25	4.059±0.31	138.22±2.71
P-value	**0.009***	0.468	0.610	0.610	0.945
Difficulty swallowing					
Yes	288.67±5.69	0.317±0.04‡	72.10±0.48	4.533±0.31	135.33±1.53
No	293.64±7.99	0.369±0.05	78.96±0.31	4.057±0.36	138.43±2.98
P-value	0.298	0.106	0.635	**0.028***	0.082
Vomitted in the last 3 days					
Yes	293.00±7.53	0.342±0.04‡	103.86±0.39‡	4.260±0.15	136.40±1.78
No	293.34±8.03	0.369±0.06	76.32±0.30	4.066±0.38	138.45±2.86
P-value	0.935	0.303	**0.038***	0.266	0.148
Consumed less fluid to manage loose bowels					
Yes	300±9.90‡	0.345±0.11	122.24±0.53‡	4.400±0.57	140.00±1.41
No	293±7.81	0.367±0.05	77.17±0.30	4.072±0.36	138.18±3.03
P-value	0.225	0.583	**0.044***	0.219	0.405
Discharged on new anti-hypertensive medication					
Yes	291.88±11.95	0.373±0.05	75.64±0.30	3.913±0.38	140.38±3.34
No	293.65±6.94	0.370±0.05	78.65±0.34	4.135±0.35	137.78±2.55
P-value	0.586	0.895	0.768	0.113	**0.018***

Independent t testing was used to test for significance.
*Significant differences between groups P≤0.05.
†Geometric mean was used.
‡ Mean outside normal reference range.
Reference ranges: creatinine 45-90umol/L, haematocrit 0.35-0.46, potassium 3.5-5.2mmol/L and sodium 135-145mmol/L as per the Waitemata DHB protocol. Serum osmolality hydrated <295mOsm/kg, impending dehydration 295-299mOsm/kg, dehydrated ≥300mOsm/kg.

3.4 Discussion

Among 54 newly hospitalised older adults mean age 82.5±8.10 years, half were found to have a low fluid intake (<1.6L), 20% were dehydrated and a further 33% were impending dehydration. These finding are similar to previous observations in the UK, which found 20% of older adults living in long term care were dehydrated and a further 28% had impending dehydration (Hooper, Bunn, Downing, et al., 2016). Similarly among hospitalised older adults in the UK, 37% were dehydrated as determined by a serum osmolality cut-off >300mOsm/kg (El-Sharkawy et al., 2015). To the best of our knowledge, this is the first study that has reported the prevalence of dehydration and fluid intake among hospitalised older adults in NZ.

Fluid intake as measured by the FIAT tool was found to be low among the hospitalised older adults in the current study; mean intake 1.8L/day for men and 1.6L/day for women. The NHMRC (2006) recommends an Adequate Intake for men over the age of 51 ofe 2.6L/day (3.4L/day total water from food and fluids) and for women over the age of 51 , 2.1L/day (2.6L/day total water from food and fluids), yet only 10% of patients in our study met these requirements. As these recommendations are based on results from the National Nutrition Survey (NNS) of Australia conducted in 1995, they should be used cautiously. Additionally adults aged 51 to 70 years and >70 years were aggregated to determine the Adequate Intakes so are not reflective of the older adult population. Nevertheless amongst this group of adults ≥51 years 75% of fluid intake came from beverages and 25% was from foods (Australian Bureau of Statistics, 1998).

The mean intake of drinking water in the current study was 0.65L for men and 0.37L for women compared to mean intakes of 0.5L-2L/day reported in older adults over 51 years either free living or living in nursing homes across seven studies worldwide (Bellisle, Thornton, Hébel, Denizeau, & Tahiri, 2010; Drewnowski et al., 2013; Ferreira-Pêgo et al., 2014; Goodman et al., 2013; Jones et al., 2006; Sebastian, Enns, & Goldman, 2011; Toffanello et al., 2010) suggesting that the mean total drinking water intake observed in the current study is low. Three studies found mean total fluid intake from water, beverages and food ranged between 1.5-3.2L/day comparable to 1.84L/day for men and 1.57L/day for women in the current study (Chidester & Spangler, 1997; Drewnowski et al., 2013; Zizza, Ellison, & Wernette, 2009).

Using a cut-point of 1.6L/day to determine adequacy of fluid intake (Gaspar, 1988, 1999; Hodgkinson et al., 2003), a third (33%) of patients in the current study who consumed less than 1.6L/day were prescribed 10 or more medications before their hospital admission, which increased to 41% of patients upon discharge. As poly-pharmacy further augments the risk of these patients developing dehydration due to their already low fluid intake (Schols et al., 2009) it is 1.6L/day were prescribed 10 or more medications before their hospital admission, which increased to 41% of patents upon discharge. As poly-pharmacy further augments the risk of these patients developing dehydration due to their already low fluid intake (Schols et al., 2009) it is important that post-discharge fluid intake is not compromised.

Furthermore, of those with low fluid intake, 26% were discharged with newly prescribed laxative medications, likely the result of constipation due to dehydration (Arnaud, 2003).

Half (56%) of the patients in the current study who consumed less than 1.6L/day perceived fluid intake to be not important or somewhat important versus 30% of the patients who consumed >1.6L/day. Previous findings, suggest older adults tend to be unaware of the significance of medical complications associated with dehydration such as low blood pressure (54%), fainting (54%), increased heart rate (58%), excessive sleepiness (70%), seizures (78%) and even death (72%) (Picetti et al., 2017). While further exploration is required, it is possible that if older adult patients are adequately informed of the important role of fluids during hospital recovery, they may be motivated to consume more fluids.

Among patients with low fluid intake (<1.6L/day), 60% struggled to open the hospital beverages; particularly foil lids on the plastic milk and juice pottles, and 63% did not seek assistance. Patients who struggled to open the fluids also had a significantly higher mean serum osmolality, indicating that they had impending dehydration. Previous studies also indicate that beverages provided in a clinical setting may be challenging for older adults to open. A study carried out in New South Wales, Australia looked at the extent at which food and beverage packaging posed a problem for older hospital patients. Among patients mean age 72 years 17% couldn't open water bottles, 12% couldn't open tetra-packs approximately 50% had some difficulty opening the milk (Bell et al., 2013). These Australian patients reported having difficulty with packaging due to arthritis (44%), a lack of hand strength (40%) and vision (35%) (Bell et al., 2013). The extra effort in opening the hospital beverages, and the lack of assistance with opening them maybe an important and modifiable factor related to low fluid intake among older patients.

In the current study, patients who had experienced vomiting within the three days of data collection, had a significantly higher mean creatinine (P=0.038) than those who hadn't experienced vomiting. While not considered the gold standard, a raised creatinine may be indicative of the presence of dehydration (Marieb & Hoehn, 2014). However this finding should be interpreted with caution due to the potential for confounding factors, such as reduced renal function and congestive heart failure (Marieb & Hoehn, 2014). We also found that patients who restricted their fluid intake to manage their diarrhoea had a significantly higher mean creatinine and a greater mean serum osmolality. Vomiting and diarrhoea have previously been widely identified as risk factors for dehydration (Bennett & Greenough, 1993;

Lavizzo-Mourey et al., 1988; Silver, 1990). Studies which have investigated the prevalence of dehydration in patients with vomiting and diarrhoea are lacking for comparison.

This study has several strengths. Patients were asked what they had to consume three times a day, minimising the likelihood of the patients forgetting and misreporting their fluid consumption. The strict exclusion criteria minimised the likelihood of confounding factors affecting their fluid intake and hydration status. The study had several limitations; firstly, due to the cross-sectional study design, causality cannot be inferred. Secondly, our findings cannot be generalised to the wider population or older adults admitted to hospitals in the Waitemata DHB. Fluid intake data was only collected for 24 hours, which is not indicative of the patient's usual fluid intake whilst in hospital. To obtain a more accurate representation, it would be appropriate to collect fluid intake data for three or more days. Future studies should use a larger sample size across a greater number of hospitals to further investigate fluid intake and gain insight into the prevalence of dehydration in NZ patients.

3.5 Conclusions

In conclusion, our results suggest that hospitalised older adults in NZ have a low fluid intake that may contribute to dehydration. Health care staff need to be made aware of the potential for dehydration and impending dehydration in older adults. Knowledge of factors that may lead to dehydration may enable early detection so that interventions can be initiated to increase the fluid intake and prevent dehydration in these patients. While specific factors were not found to significantly affect fluid intake, it was identified that the majority of patients with a low fluid intake struggled to open hospital provided fluids and did not seek assistance with opening Furthermore the patients who struggled had a higher mean serum osmolality, indicating they had impending dehydration, while those who didn't struggle had a lower mean serum osmolality, indicating they were hydrated. These findings suggest that it would be beneficial to ensure all patients are able to open the fluids provided to them. This may enable them to drink sufficient fluid to keep hydrated, aiding in their recovery, reducing their length of stay and thus the cost of their treatment.

Conflicts of interest

The author declares no conflicts of interest.

Chapter 4 – Conclusions and Recommendations

This study is the first to investigate the fluid intake, access and hydration status of hospitalised older adults in New Zealand. Fluid intake is critical for older adults due to age related changes which make them particularly vulnerable to dehydration (Begum & Johnson, 2010). Dehydration can adversely impact health status by increasing the risk of urinary tract infections, pressure sores, constipation and pneumonia (Stotts & Hopf, 2003; Warren et al., 1994; Weinberg, & Minaker, 1995). If prolonged, dehydration may cause more severe consequences including hypertension, thrombosis, cerebral infarction, mortality, and morbidity (Chan et al., 2002; Manz & Wentz, 2005). Understanding fluid intake, factors affecting fluid intake and the hydration status of hospitalised older adults is imperative for enabling early detection of dehydration. Early intervention is needed to aid the patient's recovery, reduce their length of stay and as a result reduce healthcare costs of prolonged treatment.

4.1 Fluid intake

Fluid intake as measured by the FIAT was found to be low in this sample of hospitalised older adults; mean intake 1.8L/day for men and 1.6L/day for women. The National Health and Medical Research Council recommendations for fluids are for men and women over 51 years 2.6L/day (3.4L/day total water from food and fluids) and women 2.1L/day (2.6L/day total water from food and fluids) respectively (NHMRC, 2006). However, only 10% of patients met these recommendations that are derived from data from the Australian NNS conducted in 1995. The data obtained from the Australian older adult population is now over 23 years old and is therefore not indicative of the current fluid intake of hospitalised older adults in New Zealand.

The mean intake of drinking water in the current study was 0.65L for men and 0.37L for women. A short review summarising the international data on fluid consumption in older adults (51 years and older), either free living or residing in nursing homes, found that the mean intake of drinking water recorded in seven studies ranged from 0.5-2L/day (Bellisle et al., 2010; Drewnowski et al., 2013; Ferreira-Pêgo et al., 2014; Goodman et al., 2013; Jones et al., 2006; Sebastian et al., 2011; Toffanello et al., 2010). The same short review found that the mean total fluid intake from water, other beverages and food in three studies ranged 1.5-3.2L/day (Chidester & Spangler, 1997; Drewnowski et al., 2013; Zizza et al., 2009). The current study found that the mean total fluid intake for men was 1.84L/day and for women was 1.57L/day. While total fluid intake was comparable between the current study and the findings from the short review, older adult patients from the current study had a low intake of drinking water compared to free living older adults or those living in nursing homes.

In the current study both men and women consumed the majority of their fluids in the morning (0.75L/day and 0.64L/day respectively) compared to midday (0.49L/day and 0.56L/day respectively) and the evening (0.51L/day and 0.49L/day respectively. Data from the 1992-2002 NHANES shows that non-institutionalised older adults (65 years or older) in the US also consumed the majority of their fluids in the morning (60%, 1.55L/day) compared to the afternoon (30%, 0.78L/day) and evening (10%, 0.26L/day) (Zizza et al., 2009). These findings support the theory that older adults may deliberately avoid drinking in the evening to avoid night time incontinence (Asplund & Aberg, 1991; de Castro, 1992). However, the current study explored this theory and found that although 43% of patients reported difficulties controlling their bladder, only 2% reduced their fluid intake because of this.

Findings showed the largest contributor to fluid intake for both men and women was hot beverages (0.66L/day and 0.67L/day respectively), including coffee and tea. Similarly, data from the NHANES found that coffee was the predominant beverage for older adults. Coffee contributed 38% (1.11L/day) to total fluid intake for participants aged 65-74 years, 37% (0.95L/day) for those who were 75-84 years and 40% (0.91L/day) for those who were over 85 years (Zizza et al., 2009). While some research suggests there are negative consequences of caffeine ingestion for older adults, including diuretic effects (Shirley, Walter, & Noormohamed, 2002), increased fracture frequency and bone loss (Barrett-Connor, Chang, & Edelstein, 1994; Mann & Truswell, 2007), other research has found that caffeine intake does not lead to excess fluid loss (Maughan & Griffin, 2003), increased fracture frequency or bone loss (Johansson, Mellstrom, Lerner, & Osterberg, 1992; Lloyd, Rollings, Eggli, Kieselhorst, & Chinchilli, 1997). Therefore, the Ministry of Health food and nutrition guidelines for healthy older people suggest older adults have a moderate caffeine intake of 300mg or less (Ministry of Health, 2013). This is equivalent to approximately: one large long black; three cappuccinos; four cups of plunger coffee; or six cups of tea (Massey, 2001). Despite coffee and tea being the main contributor to fluid intake in the current study, the patients consumed less than three cups of plunger coffee or tea (0.66L/day for men and 0.67L/day for women) and therefore still consumed within the moderate caffeine threshold.

4.2 Factors affecting fluid intake

Using a cut-point of 1.6L/day to determine adequacy of fluid intake (Gaspar, 1988, 1999; Hodgkinson et al., 2003), half (56%) of the patients who consumed a low fluid intake (less than 1.6L/day) and a third (30%) of patients with a higher fluid intake (more than 1.6L/day) perceived fluid intake to be not important or somewhat important. While the current study did not specifically explore the reasons why patients perceived fluid intake to be unimportant, a study looking at the health literacy of community-dwelling older adults (60 years and above) in the US found that there were significant deficiencies in the health literacy of older adults (Picetti et al., 2017). A great proportion of the older adult US participants were not aware that low blood pressure (54%), fainting (54%), increased heart rate (58%), excessive sleepiness (70%), seizures (78%) and even death (72%) could be a consequence of dehydration ($P < 0.05$) (Picetti et al., 2017). Only 34% were able to correctly identify the amount of fluid loss (3-4% of body fluid) required for the signs and symptoms of dehydration to develop. Instead majority of the older adults thought that the signs and symptoms developed when 10% or higher of body fluid was lost (Picetti et al., 2017). Therefore, it is plausible that deficiencies in hydration health literacy may have contributed to patients in the current study perceiving fluid intake to be unimportant and thus more likely to consume little fluid (less than 1.6L/day).

We found that among patients with low fluid intake (less than 1.6L/day), 60% struggled to open the hospital beverages and 63% did not seek assistance with this. Patients reported having particular difficulty with plastic milk and juice pottles due to the small tabs on the foil lids. A study by (Bell et al., 2013) also found that older adult patients (mean age 72 years) in Australia had difficulty opening the food and beverage packaging provided by the hospital. Of the Australian patients 17% couldn't open water bottles, 12% couldn't open the tetra-packs and approximately 50% had some difficulty opening the milk due to arthritis (44%), a lack of hand strength (40%) and vision (35%) (Bell et al., 2013). The extra effort in opening the hospital beverages, and the lack of assistance with opening them maybe an important and modifiable factor related to low fluid intake among older patients.

4.3 Hydration status

We found among this small group of patients 20% were dehydrated (>300mOsm/kg) and a further 33% were impending dehydration (≥295mOsm/kg-300mOsm/kg) according to their serum osmolality. Yet, dehydration has been found to be even more prevalent among hospitalised older adults (65 years or older) in the UK (El-Sharkawy et al., 2015). El-Sharkawy et al. (2015) found that among 200 hospitalised UK older adults, 37% were dehydrated on admission using a serum osmolality cut-off at >300mOsm/Kg (El-Sharkawy et al., 2015). Similarly, among 247 older adults (mean age 83 years) residing in a long-term care facility in the US, 38% were dehydrated (>300mOsm/Kg) and a further 31% were impending dehydration (≥295mOsm/kg-300mOsm/kg) (Marra et al., 2016). The prevalence of dehydration in the current study is therefore comparable to the prevalence of dehydration in older adults from other studies looking at both a clinical and long term care setting.

In the current study patients who had experienced vomiting within the three days of data collection, had a significantly higher mean creatinine than those who hadn't experienced vomiting in the last three days. A raised creatinine may be indicative of the presence of dehydration (Marieb & Hoehn, 2014), but should be interpreted with caution due the high risk of confounding factors in an older adult population group, such as reduced renal function (Marieb & Hoehn, 2014). The current study also found that patients who restricted their fluid intake to manage their diarrhoea had a significantly higher mean creatinine and a greater, yet not significant, mean serum osmolality. Vomiting and diarrhoea have previously been widely identified as risk factors for dehydration (Bennett & Greenough, 1993; Lavizzo-Mourey et al., 1988; Silver, 1990), but studies that have investigated the prevalence of vomiting, diarrhoea and dehydration in older adult patients are lacking for comparison. This warrants further investigation.

4.4 Strengths

This study has provided the first examination of fluid intake, access and hydration status in hospitalised older adults. The strict exclusion criteria and robust methods minimised the likelihood of confounding factors affecting their fluid intake and hydration status. When using the FIAT to assess fluid intake the patients were visited three times a day to report the fluids they had consumed. This minimised the risk of the patients forgetting and misreporting their fluid consumption. The FIAT contained a visual representation of all the drinks and foods with a high fluid content available on the NZ national Compass hospital menu as well as the beverages that were provided in the vending machines and cafeteria on the hospital grounds. This meant that all the different types of fluids that all the patients consumed were captured by the FIAT. Furthermore, the FIAT displayed a visual representation of the fluid measures (including jugs, mugs, cups and original product packaging) in increments of one fifth of the total item volume. This meant that the patients were able to provide an estimate, to the nearest fifth, of how much fluid was left in the measure once they had consumed the product in order for total fluid intake to be calculated.

Serum osmolality was collected within 24 hours of the FIAT data to ensure that an accurate relationship between hydration status and fluid intake could be explored. The general chemistry (sodium and potassium) and complete blood count (creatinine and haematocrit) tests were rapidly processed after collection providing accurate analysis. The sample for the serum osmolality was stored at an appropriate temperature to ensure its stability until it was processed.

4.5 Limitations

Firstly due to the cross sectional design, causality cannot be inferred. Our findings cannot be generalised to the wider population or older adults admitted to hospitals in the Waitemata DHB, as our sample was small. Fluid intake data was only collected for 24 hours, which is not indicative of the patient's usual fluid intake whilst in hospital. To obtain a more accurate representation, it would be appropriate to collect fluid intake data for three days (Karandish et al., 2016). Although the FIAT and FAST tools were only piloted on three patients before data collection commenced, the tools did not require further refinement. Pilot testing the tools on a larger number of patients would have provided greater insight into whether the patients were confused about any items or questions and whether they had any suggestions for improvement. Furthermore, the FIAT and FAST tools were unable to be validated against other reliable measures of fluid intake and access. Curently there are no standardised methods to specifically determine fluid intake and access.

The Adequate Intake (AI) for fluid intake set by the NHMRC is an out-dated estimate of the average daily fluid intake level based on the median intake of fluid from the NNS of Australia in 1995 (NHMRC, 2006). There are no recent guidelines within the last 20 years and no guidelines specifically for hospitalised older adults Internationally or in NZ.

4.6 Recommendations for future research

- Further investigate the fluid intake, factors affecting fluid intake and the hydration status of hospitalised older adults, using a larger sample size, in hospitals within and outside
- Auckland and Waitemata DHB may help broaden the findings of the present study and allow comparisons between different geographic areas of NZ.

- Recruit a greater number of ethnic participants to allow a more accurate representation of the changing ethnic diversity of an ageing population in NZ.
- Conduct the FIAT over three days to gain a more accurate representation of the patients fluid intake while in hospital (Karandish et al., 2016).
- Further investigate the fluid intake and hydration status of hospitalised older adults in NZ to create an evidenced based policy for feasible and adequate fluid intake recommendations in this particular population group.

References

Armstrong-Esther, C. A., Browne, K. D., Armstrong-Esther, D. C., & Sander, L. (1996). The institutionalized elderly: dry to the bone! *International Journal of Nursing Studies*, *33*(6), 619–628. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/8970859

Armstrong, L. E. (2005). Hydration Assessment Techniques. *Nutrition Reviews*, *63*(6), 40–54. https://doi.org/10.1301/nr.2005.jun.S40-S54

Armstrong, L. E. (2007). Assessing hydration status: the elusive gold standard. *Journal of the American College of Nutrition*, *26*(5 Suppl), 575S–584S. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/17921468

Armstrong, L. E., Soto, J. A., Hacker, F. T., Casa, D. J., Kavouras, S. A., & Maresh, C. M. (1998). Urinary indices during dehydration, exercise, and rehydration. *International Journal of Sport Nutrition*, *8*(4), 345–355. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9841955

Arnaud, M. J. (2003). Mild dehydration: a risk factor of constipation? *European Journal of Clinical Nutrition*, *57*(S2), S88–S95. https://doi.org/10.1038/sj.ejcn.1601907

Asplund, R., & Aberg, H. (1991). Diurnal variation in the levels of antidiuretic hormone in the elderly. *Journal of Internal Medicine*, *229*(2), 131–134. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/1997638

Astor, F.C., Hanft, K.L. & Ciocon, J. O. (1999). Xerostomia: A prevalent condition in the elderly. *Ear, Nose and Throat Journal*, *78*(7), 476–479. Retrieved from https://www.researchgate.net/publication/12870941_Xerostomia_A_prevalent_condition_in_the_elderly

Australian Bureau of Statistics. (1998). *National Nutrition Survey. Nutrient intakes and physical measurements. Australia 1995.* Canberra.

Bardosono, S., Monrozier, R., Permadhi, I., Manikam, N. R. M., Pohan, R., & Guelinckx, I. (2015). Total fluid intake assessed with a 7-day fluid record versus a 24-h dietary recall: a crossover study in Indonesian adolescents and adults. *European Journal of Nutrition*, *54 Suppl 2*(Suppl 2), 17–25. https://doi.org/10.1007/s00394-015-0954-6

Barrett-Connor, E., Chang, J. C., & Edelstein, S. L. (1994). Coffee-associated osteoporosis offset by daily milk consumption. The Rancho Bernardo Study. *JAMA*, *271*(4), 280–283. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/8295286

Beckman Coulter Life Sciences. (n.d.). Coulter Principle, Counting and Sizing Particles - Beckman Coulter. Retrieved March 20, 2019, from https://www.beckman.com/resources/fundamentals/history-of-flow-cytometry/the-coulter-principle

Begum, M. N., & Johnson, C. S. (2010). A review of the literature on dehydration in the institutionalized elderly. *E-SPEN, the European e-Journal of Clinical Nutrition and Metabolism*, *5*(1), e47–e53. https://doi.org/10.1016/j.eclnm.2009.10.007

Bell, A. F., Walton, K., Chevis, J. S., Davies, K., Manson, C., Wypych, A., … Alexander, N. (2013). Accessing packaged food and beverages in hospital. Exploring experiences of patients and staff. *Appetite*, *60*, 231–238. https://doi.org/10.1016/J.APPET.2012.10.013

Bellisle, F., Thornton, S. N., Hébel, P., Denizeau, M., & Tahiri, M. (2010). A study of fluid intake from beverages in a sample of healthy French children, adolescents and adults. *European Journal of Clinical Nutrition*, *64*(4), 350–355. https://doi.org/10.1038/ejcn.2010.4

Bennett, R. G., & Greenough, W. B. (1993). Approach to acute diarrhea in the elderly. *Gastroenterology Clinics of North America*, *22*(3), 517–533. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/8406728

Bhalla, A., Sankaralingam, S., Dundas, R., Swaminathan, R., Wolfe, C. D. A., & Rudd, A. G. (2000). Influence of Raised Plasma Osmolality on Clinical Outcome After Acute Stroke. *Stroke*, *31*(9), 2043–2048. https://doi.org/10.1161/01.STR.31.9.2043

Borofsky, M. S., Dauw, C. A., York, N., Terry, C., & Lingeman, J. E. (2018). Accuracy of daily fluid intake measurements using a “smart” water bottle. *Urolithiasis*, *46*(4), 343–348. https://doi.org/10.1007/s00240-017-1006-x

Burke, B. S. (1947). The dietary history as a tool in research. *Journal of the American Dietetic Association*, *23*, 1041–1046.

Burrell, L. M., Lambert, H. J., & Baylis, P. H. (1991). Effect of atrial natriuretic peptide on thirst and arginine vasopressin release in humans. *The American Journal of Physiology*, *260*(3 Pt 2), R475-9. https://doi.org/10.1152/ajpregu.1991.260.3.R475

Casa, D. J., Kavouras, S. A., Herrera, J. A., Hacker, F. T., Scheett, T. P., Stoppani, J., … Maresh, C. M. (1999). INTRAVENOUS VERSUS ORAL REHYDRATION DURING A BRIEF PERIOD: STRESS HORMONE RESPONSES TO SUBSEQUENT EXHAUSTIVE EXERCISE IN THE HEAT. *Medicine & Science in Sports & Exercise*, *31*(Supplement), S322. https://doi.org/10.1097/00005768-199905001-01610

Castell, G. S., Serra-Majem, S., & Ribas-Barba, L. (2015). What and how much do we eat? 24-hour dietary recall method. *Nutrición Hospitalaria*, *31*, 46–48. https://doi.org/10.3305/nh.2015.31.sup3.8750

Chan, J., Knutsen, S. F., Blix, G. G., Lee, J. W., & Fraser, G. E. (2002). Water, other fluids, and fatal coronary heart disease: the Adventist Health Study. *American Journal of Epidemiology*, *155*(9), 827–833. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/11978586

Cheuvront, S. N., Ely, B. R., Kenefick, R. W., & Sawka, M. N. (2010). Biological variation and diagnostic accuracy of dehydration assessment markers. *The American Journal of Clinical Nutrition*, *92*(3), 565–573. https://doi.org/10.3945/ajcn.2010.29490

Cheuvront, S. N., Kenefick, R. W., Charkoudian, N., & Sawka, M. N. (2013). Physiologic basis for understanding quantitative dehydration assessment. *The American Journal of Clinical Nutrition*, *97*(3), 455–462. https://doi.org/10.3945/ajcn.112.044172

Chidester, J. C., & Spangler, A. A. (1997). Fluid intake in the Institutionalized Elderly. *Journal of the American Dietetic Association*, *97*(1), 23–28. https://doi.org/10.1016/S0002-8223(97)00011-4

Clifton, P. M., Chan, L., Moss, C. L., Miller, M. D., & Cobiac, L. (2011). Beverage intake and obesity in Australian children. *Nutrition & Metabolism*, *8*(1), 87. https://doi.org/10.1186/1743-7075-8-87

Cohn, S. H., Vartsky, D., Yasumura, S., Sawitsky, A., Zanzi, I., Vaswani, A., & Ellis, K. J. (1980). Compartmental body composition based on total-body nitrogen, potassium, and calcium. *American Journal of Physiology-Endocrinology and Metabolism*, *239*(6), E524–E530. https://doi.org/10.1152/ajpendo.1980.239.6.E524

Cole, M. G., & McCusker, J. (2002). Treatment of Delirium in Older Medical Inpatients: A Challenge for Geriatric Specialists. *Journal of the American Geriatrics Society*, *50*(12), 2101–2103. https://doi.org/10.1046/j.1532-5415.2002.50634.x

Crawford, P. B., Obarzanek, E., Morrison, J., & Sabry, Z. I. (1994). Comparative advantage of 3-day food records over 24-hour recall and 5-day food frequency validated by observation of 9- and 10-year-old girls. *Journal of the American Dietetic Association*, *94*(6), 626–630. https://doi.org/10.1016/0002-8223(94)90158-9

Csémy, L., Sovinová, H., & Procházka, B. (2012). Alcohol consumption and marijuana use in young adult Czechs. *Central European Journal of Public Health*, *20*(4), 244–247. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/23441386

de Castro, J. M. (1992). Age-related changes in natural spontaneous fluid ingestion and thirst in humans. *Journal of Gerontology*, *47*(5), P321-30. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/1512438

Dickinson, A., Welch, C., & Ager, L. (2008). No longer hungry in hospital: improving the hospital mealtime experience for older people through action research. *Journal of Clinical Nursing*, *17*(11), 1492–1502. https://doi.org/10.1111/j.1365-2702.2007.02063.x

Drewnowski, A., Rehm, C. D., & Constant, F. (2013a). Water and beverage consumption among adults in the United States: cross-sectional study using data from NHANES 2005–2010. *BMC Public Health*, *13*(1), 1068. https://doi.org/10.1186/1471-2458-13-1068

Drewnowski, A., Rehm, C. D., & Constant, F. (2013b). Water and beverage consumption among adults in the United States: cross-sectional study using data from NHANES 2005–2010. *BMC Public Health*, *13*(1), 1068. https://doi.org/10.1186/1471-2458-13-1068

Duffey, K. J., Huybrechts, I., Mouratidou, T., Libuda, L., Kersting, M., De Vriendt, T., … HELENA Study group. (2012). Beverage consumption among European adolescents in the HELENA study. *European Journal of Clinical Nutrition*, *66*(2), 244–252. https://doi.org/10.1038/ejcn.2011.166

EFSA Panel in Dietetic Products, Nutrition, and A. (2010). Scientific Opinion on Dietary Reference Values for water. *EFSA Journal*, *8*(3). https://doi.org/10.2903/j.efsa.2010.1459

EFSA Panel on Dietetic Products, Nutrition, and A. (NDA). (2010). Scientific Opinion on Dietary Reference Values for water. *EFSA Journal*, *8*(3). https://doi.org/10.2903/j.efsa.2010.1459

El-Sharkawy, A. M., Sahota, O., Maughan, R. J., & Lobo, D. N. (2014). The pathophysiology of fluid and electrolyte balance in the older adult surgical patient. *Clinical Nutrition*, *33*(1), 6–13. https://doi.org/10.1016/J.CLNU.2013.11.010

El-Sharkawy, A. M., Watson, P., Neal, K. R., Ljungqvist, O., Maughan, R. J., Sahota, O., & Lobo, D. N. (2015a). Hydration and outcome in older patients admitted to hospital (The HOOP prospective cohort study). *Age and Ageing*, *44*(6), 943–947. https://doi.org/10.1093/ageing/afv119

El-Sharkawy, A. M., Watson, P., Neal, K. R., Ljungqvist, O., Maughan, R. J., Sahota, O., & Lobo, D. N. (2015b). Hydration and outcome in older patients admitted to hospital (The HOOP prospective cohort study). *Age and Ageing*, *44*(6), 943–947. https://doi.org/10.1093/ageing/afv119

Feinsod, F. M., Levenson, S. A., Rapp, K., Rapp, M. P., Beechinor, E., & Liebmann, L. (2004). Dehydration in Frail, Older Residents in Long-Term Care Facilities. *Journal of the American Medical Directors Association*, *5*(Supplement), S36–S41. https://doi.org/10.1097/01.JAM.0000036697.72589.A8

Ferreira-Pêgo, C., Babio, N., Fenández-Alvira, J. M., Iglesia, I., Moreno, L. A., & Salas-Salvadó, J. (2014). Fluid intake from beverages in Spanish adults; cross-sectional study. *Nutricion Hospitalaria*, *29*(5), 1171–1178. https://doi.org/10.3305/nh.2014.29.5.7421

Fortes, M. B., Owen, J. A., Raymond-Barker, P., Bishop, C., Elghenzai, S., Oliver, S. J., & Walsh, N. P. (2015). Is This Elderly Patient Dehydrated? Diagnostic Accuracy of Hydration Assessment Using Physical Signs, Urine, and Saliva Markers. *Journal of the American Medical Directors Association*, *16*(3), 221–228. https://doi.org/10.1016/J.JAMDA.2014.09.012

Fried, L. F., & Palevsky, P. M. (1997). HYPONATREMIA AND HYPERNATREMIA. *Medical Clinics of North America*, *81*(3), 585–609. https://doi.org/10.1016/S0025-7125(05)70535-6

Fries, B. E., Hawes, C., Morris, J. N., Phillips, C. D., Mor, V., & Park, P. S. (1997). Effect of the National Resident Assessment Instrument on Selected Health Conditions and Problems. *Journal of the American Geriatrics Society*, *45*(8), 994–1001. https://doi.org/10.1111/j.1532-5415.1997.tb02972.x

Garriguet, D. (2008a). Beverage consumption of Canadian adults. *Health Reports*, *19*(4), 23–29. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/19226924

Garriguet, D. (2008b). Beverage consumption of children and teens. *Health Reports*, *19*(4), 17–22. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/19226923

Gaspar, P. . (1988). What determines how much patients drink? *Geriatric Nursing*, *9*(4), 221–224.

Gaspar, P. . (1999). Water Intake of Nursing Home Residents. *Journal of Gerontological Nursing*, *25*(4), 23–29.

Gibson, R. S. (2005). *Principles of Nutritional Assessment* (2nd ed.). New York: Oxford University Press.

Godfrey, H., Cloete, J., Dymond, E., & Long, A. (2012a). An exploration of the hydration care of older people: A qualitative study. *International Journal of Nursing Studies*, *49*(10), 1200–1211. https://doi.org/10.1016/j.ijnurstu.2012.04.009

Godfrey, H., Cloete, J., Dymond, E., & Long, A. (2012b). An exploration of the hydration care of older people: A qualitative study. *International Journal of Nursing Studies*, *49*(10), 1200–1211. https://doi.org/10.1016/j.ijnurstu.2012.04.009

Gómez-Martínez, S., Martín, A., Romeo, J., Castillo, M., Mesena, M., Baraza, J. C., … Marcos, A. (2009). Is soft drink consumption associated with body composition? A cross-sectional study in Spanish adolescents. *Nutricion Hospitalaria*, *24*(1), 97–102. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/19266121

Goodman, A. B., Blanck, H. M., Sherry, B., Park, S., Nebeling, L., & Yaroch, A. L. (2013). Behaviors and Attitudes Associated With Low Drinking Water Intake Among US Adults, Food Attitudes and Behaviors Survey, 2007. *Preventing Chronic Disease*, *10*, 120248. https://doi.org/10.5888/pcd10.120248

Gopinathan, P. M., Pichan, G., & Sharma, V. M. (1988). Role of Dehydration in Heat Stress-Induced Variations in Mental Performance. *Archives of Environmental Health: An International Journal*, *43*(1), 15–17. https://doi.org/10.1080/00039896.1988.9934367

Greenspan, D. (1996). Xerostomia: Diagnosis and Management. *Oncology*, *10*(3), 7–11. Retrieved from https://www.researchgate.net/publication/14479842_Xerostomia_Diagnosis_and_Management

Guelinckx, I., Tavoularis, G., König, J., Morin, C., Gharbi, H., & Gandy, J. (2016). Contribution of Water from Food and Fluids to Total Water Intake: Analysis of a French and UK Population Surveys. *Nutrients*, *8*(10). https://doi.org/10.3390/nu8100630

Hawkins, R. C. (2003). Age and gender as risk factors for hyponatremia and hypernatremia. *Clinica Chimica Acta*, *337*(1–2), 169–172. https://doi.org/10.1016/J.CCCN.2003.08.001

Heavens, K. R., Kenefick, R. W., Caruso, E. M., Spitz, M. G., & Cheuvront, S. N. (2014). Validation of equations used to predict plasma osmolality in a healthy adult cohort. *The American Journal of Clinical Nutrition*, *100*(5), 1252–1256. https://doi.org/10.3945/ajcn.114.091009

Hedrick, V. E., Comber, D. L., Estabrooks, P. A., Savla, J., & Davy, B. M. (2010). The beverage intake questionnaire: determining initial validity and reliability. *Journal of the American Dietetic Association*, *110*(8), 1227–1232. https://doi.org/10.1016/j.jada.2010.05.005

Hedrick, V. E., Savla, J., Comber, D. L., Flack, K. D., Estabrooks, P. A., Nsiah-Kumi, P. A., … Davy, B. M. (2012). Development of a Brief Questionnaire to Assess Habitual Beverage Intake (BEVQ-15): Sugar-Sweetened Beverages and Total Beverage Energy Intake. *Journal of the Academy of Nutrition and Dietetics*, *112*(6), 840–849. https://doi.org/10.1016/J.JAND.2012.01.023

Hodgkinson, B., Evans, D., & Wood, J. (2003). Maintaining oral hydration in older adults: a systematic review. *International Journal of Nursing Practice*, *9*(3), S19-28. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/12801253

Hoffman, N. B. (1991). Dehydration in the elderly: insidious and manageable. *Geriatrics*, *46*(6), 35–38. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/2040458

Hooper, L., Abdelhamid, A., Attreed, N. J., Campbell, W. W., Channell, A. M., Chassagne, P., … Hunter, P. (2015). Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people. *Cochrane Database of Systematic Reviews*, (4). https://doi.org/10.1002/14651858.CD009647.pub2

Hooper, L., Bunn, D., Jimoh, F. O., & Fairweather-Tait, S. J. (2014a). Water-loss dehydration and aging. *Mechanisms of Ageing and Development*, *136–137*, 50–58. https://doi.org/10.1016/J.MAD.2013.11.009

Hooper, L., Bunn, D., Jimoh, F. O., & Fairweather-Tait, S. J. (2014b). Water-loss dehydration and aging. *Mechanisms of Ageing and Development*, *136–137*, 50–58. https://doi.org/10.1016/J.MAD.2013.11.009

Hooper, L., Bunn, D. K., Abdelhamid, A., Gillings, R., Jennings, A., Maas, K., … Fairweather-Tait, S. J. (2016). Water-loss (intracellular) dehydration assessed using urinary tests: how well do they work? Diagnostic accuracy in older people. *The American Journal of Clinical Nutrition*, *104*(1), 121–131. https://doi.org/10.3945/ajcn.115.119925

Hooper, L., Bunn, D. K., Downing, A., Jimoh, F. O., Groves, J., Free, C., … Shepstone, L. (2016). Which Frail Older People Are Dehydrated? The UK DRIE Study. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *71*(10), 1341–1347. https://doi.org/10.1093/gerona/glv205

Inoue, Y., Shibasaki, M., Hirata, K., & Araki, T. (1998). Relationship between skin blood flow and sweating rate, and age related regional differences. *European Journal of Applied Physiology*, *79*(1), 17–23. https://doi.org/10.1007/s004210050467

Institute of Medicine (U.S.). (2005a). *Dietary Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate*. Washington, D.C.: National Academies Press. https://doi.org/10.17226/10925

Institute of Medicine (U.S.). (2005b). *Panel on Dietary Reference Intakes for Electrolytes and Water*. Retrieved from http://www.nap.edu.

Johansson, C., Mellstrom, D., Lerner, U., & Osterberg, T. (1992). Coffee Drinking: A Minor Risk Factor for Bone Loss and Fractures. *Age and Ageing*, *21*(1), 20–26.

Johnstone, P., Alexander, R., & Hickey, N. (2015). Prevention of dehydration in hospital inpatients. *British Journal of Nursing*, *24*(11), 568–573. https://doi.org/10.12968/bjon.2015.24.11.568

Jones, A. Q., Dewey, C. E., Doré, K., Majowicz, S. E., McEwen, S. A., & Waltner-Toews, D. (2006). Drinking water consumption patterns of residents in a Canadian community. *Journal of Water and Health*, *4*(1), 125–138. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/16604844

Kant, A. K., Graubard, B. I., & Atchison, E. A. (2009). Intakes of plain water, moisture in foods and beverages, and total water in the adult US population—nutritional, meal pattern, and body weight correlates: National Health and Nutrition Examination Surveys 1999–2006. *The American Journal of Clinical Nutrition*, *90*(3), 655–663. https://doi.org/10.3945/ajcn.2009.27749

Karandish, M., Zilaee, M., Momeni, A., & Fathi, M. (2016). Determining the Correlation Between Three and Seven day Records of Fluids Consumption to Determine an Appropriate Method for Estimating the Amount and Type of FLuids Intake in Adults. *Jundishapur Journal of Health Sciences*, *9*(1).

Kavouras, S. A. (2002). Assessing hydration status. *Current Opinion in Clinical Nutrition and Metabolic Care*, *5*(5), 519–524. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/12172475

Kayser-Jones, J., Schell, E. S., Porter, C., Barbaccia, J. C., & Shaw, H. (1999). Factors contributing to dehydration in nursing homes: inadequate staffing and lack of professional supervision. *Journal of the American Geriatrics Society*, *47*(10), 1187–1194. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/10522951

Kenkmann, A., Price, G. M., Bolton, J., & Hooper, L. (2010). Health, wellbeing and nutritional status of older people living in UK care homes: an exploratory evaluation of changes in food and drink provision. *BMC Geriatrics*, *10*, 28. https://doi.org/10.1186/1471-2318-10-28

Kenney, W. L., & Fowler, S. R. (1988). Methylcholine-activated eccrine sweat gland density and output as a function of age. *Journal of Applied Physiology (Bethesda, Md. : 1985)*, *65*(3), 1082–1086. https://doi.org/10.1152/jappl.1988.65.3.1082

Kleiner, S. M. (1999). Water: An Essential But Overlooked Nutrient. *Journal of the American Dietetic Association*, *99*(2), 200–206. https://doi.org/10.1016/S0002-8223(99)00048-6

Kositzke, J. A. (1990). A question of balance--dehydration in the elderly. *Journal of Gerontological Nursing*, *16*(5), 4–11. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/2358648

Kovacs, E.M.R., Senden, J.M.G., & Brouns, F. (1999). Urine color, osmolality and specific electrical conductance are not accurate measures of hydration status during postexercise rehydration. *The Journal of Sports Medicine and Physical Fitness.* , *39*(1), 47–53. Retrieved from https://www.researchgate.net/publication/13068747_Urine_color_osmolality_and_specific_electrical_conductance_are_not_accurate_measures_of_hydration_status_during_postexercise_rehydration

Lapides, J., Bourne, R. B., & Maclean, L. R. (1965). CLINICAL SIGNS OF DEHYDRATION AND EXTRACELLULAR FLUID LOSS. *JAMA*, *191*, 413–415. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/14232452

Lavizzo-Mourey, R., Johnson, J., & Stolley, P. (1988). Risk factors for dehydration among elderly nursing home residents. *Journal of the American Geriatrics Society*, *36*(3), 213–218. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/3339229

Lindeman, R. D., Tobin, J., & Shock, N. W. (1985). Longitudinal Studies on the Rate of Decline in Renal Function with Age. *Journal of the American Geriatrics Society*, *33*(4), 278–285. https://doi.org/10.1111/j.1532-5415.1985.tb07117.x

Lloyd, T., Rollings, N., Eggli, D. F., Kieselhorst, K., & Chinchilli, V. M. (1997). Dietary caffeine intake and bone status of postmenopausal women. *The American Journal of Clinical Nutrition*, *65*(6), 1826–1830. https://doi.org/10.1093/ajcn/65.6.1826

Mahan, L. K., & Raymond, J. L. (2017). *Krause's food and the nutrition care process* (14th ed.). St. Louis, Missouri: Elsevier.

Malisova, O., Bountziouka, V., Panagiotakos, D. B., Zampelas, A., & Kapsokefalou, M. (2012). The water balance questionnaire: design, reliability and validity of a questionnaire to evaluate water balance in the general population. *International Journal of Food Sciences and Nutrition*, *63*(2), 138–144. https://doi.org/10.3109/09637486.2011.607799

Mange, K., Matsuura, D., Cizman, B., Soto, H., Ziyadeh, F. N., Goldfarb, S., & Neilson, E. G. (1997). Language Guiding Therapy: The Case of Dehydration versus Volume Depletion. *Annals of Internal Medicine*, *127*(9), 848. https://doi.org/10.7326/0003-4819-127-9-199711010-00020

Mann, J., & Truswell, A. S. (2007). *Essentials of human nutrition* (3rd ed.). Oxford University Press.

Manz, F., & Wentz, A. (2005). The importance of good hydration for the prevention of chronic diseases. *Nutrition Reviews*, *63*(6 Pt 2), S2-5. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/16028566

Marieb, E. N., & Hoehn, K. (2014). *Human Anatomy & Physiology* (9th ed.). Essex: Pearson Education Limited.

Marra, M. V., Simmons, S. F., Shotwell, M. S., Hudson, A., Hollingsworth, E. K., Long, E., … Silver, H. J. (2016). Elevated Serum Osmolality and Total Water Deficit Indicate Impaired Hydration Status in Residents of Long-Term Care Facilities Regardless of Low or High Body Mass Index. *Journal of the Academy of Nutrition and Dietetics*, *116*(5), 828–836.e2. https://doi.org/10.1016/j.jand.2015.12.011

Marshall, T. A., Eichenberger Gilmore, J. M., Broffitt, B., Levy, S. M., & Stumbo, P. J. (2003). Relative validation of a beverage frequency questionnaire in children ages 6 months through 5 years using 3-day food and beverage diaries. *Journal of the American Dietetic Association*, *103*(6), 714–720. https://doi.org/10.1053/JADA.2003.50137

Marshall, T. A., Eichenberger Gilmore, J. M., Broffitt, B., Stumbo, P. J., & Levy, S. M. (2008). Relative Validity of the Iowa Fluoride Study Targeted Nutrient Semi-Quantitative Questionnaire and the Block Kids' Food Questionnaire for Estimating Beverage, Calcium, and Vitamin D Intakes by Children. *Journal of the American Dietetic Association*, *108*(3), 465–472. https://doi.org/10.1016/J.JADA.2007.12.002

Massey, L. K. (2001). Is caffeine a risk factor for bone loss in the elderly? *The American Journal of Clinical Nutrition*, *74*(5), 569–570. https://doi.org/10.1093/ajcn/74.5.569

Mathiowetz, V., Kashman, N., Volland, G., Weber, K., Dowe, M., & Rogers, S. (1985). Grip and pinch strength: normative data for adults. *Archives of Physical Medicine and Rehabilitation*, *66*(2), 69–74. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/3970660

Maughan, R. J. (2003). Impact of mild dehydration on wellness and on exercise performance. *European Journal of Clinical Nutrition*, *57*(S2), S19–S23. https://doi.org/10.1038/sj.ejcn.1601897

Maughan, R. J., & Griffin, J. (2003). Caffeine ingestion and fluid balance: a review. *Journal of Human Nutrition and Dietetics*, *16*(6), 411–420. https://doi.org/10.1046/j.1365-277X.2003.00477.x

McCullough, J., & Keller, H. (2018). The My Meal Intake Tool (M-MIT): Validity of a Patient Self-Assessment for Food and Fluid Intake at a Single Meal. *The Journal of Nutrition, Health & Aging*, *22*(1), 30–37. https://doi.org/10.1007/s12603-016-0859-y

McGee, S., III, W. B. A., & Simel, D. L. (1999). Is This Patient Hypovolemic? *JAMA*, *281*(11), 1022. https://doi.org/10.1001/jama.281.11.1022

McKenzie, A. L., Muñoz, C. X., & Armstrong, L. E. (2015). Accuracy of Urine Color to Detect Equal to or Greater Than 2% Body Mass Loss in Men. *Journal of Athletic Training*, *50*(12), 1306–1309. https://doi.org/10.4085/1062-6050-51.1.03

Mentes, J. (2006). Oral Hydration in Older Adults. *AJN, American Journal of Nursing*, *106*(6), 40–49. https://doi.org/10.1097/00000446-200606000-00023

Mentes, J. C., Wakefield, B., & Culp, K. (2006). Use of a Urine Color Chart to Monitor Hydration Status in Nursing Home Residents. *Biological Research For Nursing*, *7*(3), 197–203. https://doi.org/10.1177/1099800405281607

Miller, M. (1997). Fluid and electrolyte homeostasis in the elderly: Physiological changes of ageing and clinical consequences. *Baillière's Clinical Endocrinology and Metabolism*, *11*(2), 367–387. https://doi.org/10.1016/S0950-351X(97)80347-3

Ministry of Health. (2013). *Food and Nutrition Guidelines for Healthy Older People*. Wellington.

Ministry of Health. (2014). Tagata Pasifika in New Zealand.

Ministry of Social Development. (n.d.). Our ageing population - Super Seniors. Retrieved February 11, 2019, from http://www.superseniors.msd.govt.nz/about-supersenoirs/media/key-statistics.html

Minson, C. T., Wladkowski, S. L., Cardell, A. F., Pawelczyk, J. A., & Kenney, W. L. (1998). Age alters the cardiovascular response to direct passive heating. *Journal of Applied Physiology*, *84*(4), 1323–1332. https://doi.org/10.1152/jappl.1998.84.4.1323

Monnerie, B., Tavoularis, L. G., Guelinckx, I., Hebel, P., Boisvieux, T., Cousin, A., & Le Bellego, L. (2015). A cross-over study comparing an online versus a paper 7-day food record: focus on total water intake data and participant's perception of the records. *European Journal of Nutrition*, *54*(S2), 27–34. https://doi.org/10.1007/s00394-015-0945-7

Mueller, C., Miller, S., Schwartz, D., Kovacevich, D., & McClave, S. (2012). *The A.S.P.E.N. adult nutrition support core curriculum* (2nd ed.).

National Health and Medical Research Council. (1999). *Dietary Guidelines for older Australians*. Retrieved from https://pdfs.semanticscholar.org/4243/cebfdfb66be2ba60f108313a4b1922dcdbc0.pdf

National Health and Medical Research Council. (2013). *Dietary Guidelines for Australian Adults. A guide to healthy eating*. Canberra. Retrieved from http://www.nhmrc.gov.au

Nelson, M. C., & Lytle, L. A. (2009). Development and Evaluation of a Brief Screener to Estimate Fast-Food and Beverage Consumption among Adolescents. *Journal of the American Dietetic Association*, *109*(4), 730–734. https://doi.org/10.1016/J.JADA.2008.12.027

New Zealand. Statistics New Zealand. (n.d.). 2013 quickstats. About people aged 65 and over. Retrieved June 16, 2019, from http://archive.stats.govt.nz/Census/2013-census/profile-and-summary-reports/quickstats-65-plus.aspx

NHMRC. (2006). *Nutrient reference values for Australia and New Zealand: including recommended dietary intakes*. Canberra (National Health and Medical Research) and Wellington (Ministry of Health).

Nordic Council of Ministers. (2012). *Nordic Nutrition Recommendations 2012*. Retrieved from https://norden.diva-portal.org/smash/get/diva2:704251/FULLTEXT01.pdf

Nyengaard, J. R., & Bendtsen, T. F. (1992). Glomerular number and size in relation to age, kidney weight, and body surface in normal man. *The Anatomical Record*, *232*(2), 194–201. https://doi.org/10.1002/ar.1092320205

O'Brien, C., Baker-Fulco, C. J., Young, A. J., & Sawka, M. N. (1999). Bioimpedance assessment of hypohydration. *Medicine and Science in Sports and Exercise*, *31*(10), 1466–1471. https://doi.org/10.1097/00005768-199910000-00017

Özen, A. E., Bibiloni, M. del M., Pons, A., & Tur, J. A. (2015). Fluid intake from beverages across age groups: a systematic review. *Journal of Human Nutrition and Dietetics*, *28*(5), 417–442. https://doi.org/10.1111/jhn.12250

Pash, E., Parikh, N., & Hashemi, L. (2014). Economic Burden Associated With Hospital Postadmission Dehydration. *Journal of Parenteral and Enteral Nutrition*, *38*(2_suppl), 58S–64S. https://doi.org/10.1177/0148607114550316

Perrier, E., Vergne, S., Klein, A., Poupin, M., Rondeau, P., Le Bellego, L., … Tack, I. (2013). Hydration biomarkers in free-living adults with different levels of habitual fluid consumption. *The British Journal of Nutrition*, *109*(9), 1678–1687. https://doi.org/10.1017/S0007114512003601

Petrofsky, J. S., Lohman III, E., Hye, J. S., Garcia, J., Anders, A., Sutterfield, C., … Khandge, C. (2006). Determination of the conductive heat exchange of the skin in relation to environmental temperature. *The Journal of Applied Research*, *6*(2), 157–169. Retrieved from https://www.researchgate.net/publication/287914046_Determination_of_the_conductive_heat_exchange_of_the_skin_in_relation_to_environmental_temperature

Phillips, P. A., Bretherton, M., Risvanis, J., Casley, D., Johnston, C., & Gray, L. (1993). Effects of drinking on thirst and vasopressin in dehydrated elderly men. *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology*, *264*(5), R877–R881. https://doi.org/10.1152/ajpregu.1993.264.5.R877

Philpin, S., Merrell, J., Warring, J., Gregory, V., & Hobby, D. (2011). Sociocultural context of nutrition in care homes. *Nursing Older People*, *23*(4), 24–30. https://doi.org/10.7748/nop2011.05.23.4.24.c8480

Picetti, D., Foster, S., Pangle, A. K., Schrader, A., George, M., Wei, J. Y., & Azhar, G. (2017). Hydration health literacy in the elderly. *Nutrition and Healthy Aging*, *4*(3), 227–237. https://doi.org/10.3233/NHA-170026

Popkin, B. M., D'Anci, K. E., & Rosenberg, I. H. (2010). Water, hydration, and health. *Nutrition Reviews*, *68*(8), 439–458. https://doi.org/10.1111/j.1753-4887.2010.00304.x

Rhoda, K. M., Porter, M. J., & Quintini, C. (2011). Fluid and Electrolyte Management. *Journal of Parenteral and Enteral Nutrition*, *35*(6), 675–685. https://doi.org/10.1177/0148607111421913

Ribas-Barba, L., Serra-Majem, L., Salvador, G., Castell, C., Cabezas, C., Salleras, L., & Plasencia, A. (2007). Trends in dietary habits and food consumption in Catalonia, Spain (1992–2003). *Public Health Nutrition*, *10*(11A), 1340–1353. https://doi.org/10.1017/S136898000700095X

Rikkert, M. G. M. O., Melis, R. J. F., & Claassen, J. A. H. R. (2009). Heat waves and dehydration in the elderly. *BMJ*, *339*, b2663. https://doi.org/10.1136/BMJ.B2663

Roche, S. M., Jones, A. Q., Majowicz, S. E., McEwen, S. A., & Pintar, K. D. M. (2012). Drinking water consumption patterns in Canadian communities (2001–2007). *Journal of Water and Health*, *10*(1), 69–86. https://doi.org/10.2166/wh.2011.051

Rowat, A., Smith, L., Graham, C., Lyle, D., Horsburgh, D., & Dennis, M. (2011). A pilot study to assess if urine specific gravity and urine colour charts are useful indicators of dehydration in acute stroke patients. *Journal of Advanced Nursing*, *67*(9), 1976–1983. https://doi.org/10.1111/j.1365-2648.2011.05645.x

Sarhill, N., Walsh, D., Nelson, K., & Davis, M. (2001). Evaluation and treatment of cancer-related fluid deficits: volume depletion and dehydration. *Supportive Care in Cancer : Official Journal of the Multinational Association of Supportive Care in Cancer*, *9*(6), 408–419. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/11585267

Sawka, M. N., Cheuvront, S. N., & Carter, R. (2005). Human Water Needs, 30–39. https://doi.org/10.1301/nr.2005.jun.S30

Schenker, S. (2003). *Undernutrition in the UK. Blackwell Science*. Retrieved from https://www.nutrition.org.uk/attachments/153_Undernutrition in the UK.pdf

Scherer, R., Maroto-Sanchez, B., Palacios, G., & Gonzalez-Gross, M. (2016). Fluid intake and recommendations in older adults: More data are needed. *Nutrition BUlletin*, *41*, 167–174.

Schols, J. M. G. A., Groot, C. P. G. M., Cammen, T. J. M., & Olde Rikkert, M. G. M. (2009). Preventing and treating dehydration in the elderly during periods of illness and warm weather. *The Journal of Nutrition, Health and Aging*, *13*(2), 150–157. https://doi.org/10.1007/s12603-009-0023-z

Sebastian, R. S., Enns, C. W., & Goldman, J. . (2011). *Drinking Water Intake in the U.S. What We Eat In America, NHANES 2005-2008*. Retrieved from www.ars.usda.gov/ba/bhnrc/fsrg

Shimizu, M., Kinoshita, K., Hattori, K., Ota, Y., Kanai, T., Kobayashi, H., & Tokuda, Y. (2012). Physical signs of dehydration in the elderly. *Internal Medicine (Tokyo, Japan)*, *51*(10), 1207–1210. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/22687791

Shirley, D. G., Walter, S. J., & Noormohamed, F. H. (2002). Natriuretic effect of caffeine: assessment of segmental sodium reabsorption in humans. *Clinical Science (London, England : 1979)*, *103*(5), 461–466. https://doi.org/10.1042/

Shirreffs, S. M. (2003). Markers of hydration status. *European Journal of Clinical Nutrition*, *57*(S2), S6–S9. https://doi.org/10.1038/sj.ejcn.1601895

Shirreffs, S. M., Merson, S. J., Fraser, S. M., & Archer, D. T. (2004). The effects of fluid restriction on hydration status and subjective feelings in man. *British Journal of Nutrition*, *91*(06), 951. https://doi.org/10.1079/BJN20041149

Silver, A. J. (1990). *Aging and risks for dehydration* (Vol. 57). Retrieved from https://mdedge-files-live.s3.us-east-2.amazonaws.com/files/s3fs-public/issues/articles/media_5f44aed_ccjm57_4-0341.pdf

Simmons, S. F., Alessi, C., & Schnelle, J. F. (2001). An intervention to increase fluid intake in nursing home residents: prompting and preference compliance. *Journal of the American Geriatrics Society*, *49*(7), 926–933. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/11527484

Simmons, S. F., Osterweil, D., & Schnelle, J. F. (2001). Improving food intake in nursing home residents with feeding assistance: a staffing analysis. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, *56*(12), M790-4. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/11723156

Snyder, J., Goepp, J., Katz, S., & Santosham, M. (1997). Use and Misuse of Oral Therapy for Diarrhea: Comparison of US Practices With American Academy of Pediatrics Recommendations. *Pediatrics*, *87*(1), 28–33. https://doi.org/10.1542/peds.99.5.e6

Steiner, M. J., Dewalt, D. A., Byerley, J. S., & Alerts, E. (2004). Is This Child Dehydrated? *JAMA: The Journal of the American Medical Association*, *291*(22), 2746–2754. https://doi.org/10.1001/jama.291.22.2746

Stookey, J. D., Purser, J. L., Pieper, C. F., & Cohen, H. J. (2004). Plasma Hypertonicity: Another Marker of Frailty? *Journal of the American Geriatrics Society*, *52*(8), 1313–1320. https://doi.org/10.1111/j.1532-5415.2004.52361.x

Stotts, N. A., & Hopf, H. W. (2003). The link between tissue oxygen and hydration in nursing home residents with pressure ulcers: Preliminary data. *Journal of WOCN*, *30*(4), 184–190. https://doi.org/10.1067/MJW.2003.132

Thomas, D. R., Cote, T. R., Lawhorne, L., Levenson, S. A., Rubenstein, L. Z., Smith, D. A., … Dehydration Council. (2008a). Understanding clinical dehydration and its treatment. *Journal of the American Medical Directors Association*, *9*(5), 292–301. https://doi.org/10.1016/j.jamda.2008.03.006

Thomas, D. R., Cote, T. R., Lawhorne, L., Levenson, S. A., Rubenstein, L. Z., Smith, D. A., … Dehydration Council. (2008b). Understanding Clinical Dehydration and Its Treatment. *Journal of the American Medical Directors Association*, *9*(5), 292–301. https://doi.org/10.1016/j.jamda.2008.03.006

Thomas, D. R., Tariq, S. H., Makhdomm, S., Haddad, R., & Moinuddin, A. (2003). Physician Misdiagnosis of Dehydration in Older Adults. *Journal of the American Medical Directors Association*, *4*(5), 251–254. https://doi.org/10.1016/S1525-8610(04)70368-0

Toffanello, E. D., Inelmen, E. M., Minicuci, N., Campigotto, F., Sergi, G., Coin, A., … Manzato, E. (2010). Ten-year trends in dietary intake, health status and mortality rates in free-living elderly people. *The Journal of Nutrition, Health & Aging*, *14*(4), 259–264. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/20305991

Ullrich, S., & McCutcheon, H. (2008). Nursing practice and oral fluid intake of older people with dementia. *Journal of Clinical Nursing*, *17*(21), 2910–2919. https://doi.org/10.1111/j.1365-2702.2007.02274.x

Vergne, S. (2012). Methodological Aspects of Fluid Intake Records and Surveys. *Nutrition Today*, *47*, S7–S10. https://doi.org/10.1097/NT.0b013e31826264b4

Vivanti, A. (2007). *Screening and Identification of Dehydration In Older People Admitted to a Geriatric and Rehabilitation Unit*. Retrieved from https://eprints.qut.edu.au/16635/1/Angela_Vivanti_Thesis.pdf

Vivanti, A., Harvey, K., & Ash, S. (2010). Developing a quick and practical screen to improve the identification of poor hydration in geriatric and rehabilitative care. *Archives of Gerontology and Geriatrics*, *50*(2), 156–164. https://doi.org/10.1016/j.archger.2009.03.003

Vivanti, A., Harvey, K., Ash, S., & Battistutta, D. (2008). Clinical assessment of dehydration in older people admitted to hospital: What are the strongest indicators? *Archives of Gerontology and Geriatrics*, *47*(3), 340–355.

Vivanti, A., Yu, L., Palmer, M., Dakin, L., Sun, J., & Campbell, K. (2013). Short-term body weight fluctuations in older well-hydrated hospitalised patients. *Journal of Human Nutrition and Dietetics*, *26*(5), 429–435. https://doi.org/10.1111/jhn.12034

Volkert, D., Beck, A. M., Cederholm, T., Cruz-Jentoft, A., Goisser, S., Hooper, L., … Bischoff, S. C. (2018). ESPEN Guideline ESPEN guideline on clinical nutrition and hydration in geriatrics. *Clinical Nutrition*. https://doi.org/10.1016/j.clnu.2018.05.024

Voorbij, A. I. ., & Steenbekkers, L. P. . (2002). The twisting force of aged consumers when opening a jar. *Applied Ergonomics*, *33*(1), 105–109. https://doi.org/10.1016/S0003-6870(01)00028-X

W. Larry Kenney, P. C. (2001). Influence of age on thirst and fluid intake. *Medicine &amp*, *33*(9), 1524–1532. Retrieved from https://insights.ovid.com/crossref?an=00005768-200109000-00016

Waitemata District Health Board. (n.d.). About DHBs | Waitemata District Health Board (WDHB). Retrieved March 19, 2019, from https://www.waitematadhb.govt.nz/about-us/about-dhbs/

Wakefield, B., Mentes, J., Diggelmann, L., & Culp, K. (2002). Monitoring Hydration Status in Elderly Veterans. *Western Journal of Nursing Research*, *24*(2), 132–142. https://doi.org/10.1177/01939450222045798

Warren, J. L., Bacon, W. E., Harris, T., McBean, A. M., Foley, D. J., & Phillips, C. (1994). The burden and outcomes associated with dehydration among US elderly, 1991. *American Journal of Public Health*, *84*(8), 1265–1269. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/8059883

Weinberg, A. D., & Minaker, K. L. (1995). Dehydration. Evaluation and management in older adults. Council on Scientific Affairs, American Medical Association. *JAMA: The Journal of the American Medical Association*, *274*(19), 1552–1556. https://doi.org/10.1001/jama.274.19.1552

Weinberg, A. D., Minaker, K. L., Coble, Y. D., Davis, R. M., Head, C. A., Howe, J. P., … Rinaldi, R. C. (1995). Dehydration. *JAMA*, *274*(19), 1552. https://doi.org/10.1001/jama.1995.03530190066035

Westaway, K., Frank, O., Husband, A., McClure, A., Shute, R., Edwards, S., … Rowett, D. (2015a). Medicines can affect thermoregulation and accentuate the risk of dehydration and heat-related illness during hot weather. *Journal of Clinical Pharmacy and Therapeutics*, *40*(4), 363–367. https://doi.org/10.1111/jcpt.12294

Westaway, K., Frank, O., Husband, A., McClure, A., Shute, R., Edwards, S., … Rowett, D. (2015b). Medicines can affect thermoregulation and accentuate the risk of dehydration and heat-related illness during hot weather. *Journal of Clinical Pharmacy and Therapeutics*, *40*(4), 363–367. https://doi.org/10.1111/jcpt.12294

Whitmire, S. J. (2008). Nutrition-Focused Evaluation and Management of Dysnatremias. *Nutrition in Clinical Practice*, *23*(2), 108–121. https://doi.org/10.1177/0884533608314531

Williams, M. E., & Pannill, F. C. (1982). Urinary incontinence in the elderly: physiology, pathophysiology, diagnosis, and treatment. *Annals of Internal Medicine*, *97*(6), 895–907. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/6184002

Xiao, H., & Barber, J. (2004). *Economic burden of dehydration among hospitalized elderly patients*. *Article in American Journal of Health*. Retrieved from https://www.researchgate.net/publication/8134463

Yoxall, A., Janson, R., Bradbury, S. R., Langley, J., Wearn, J., & Hayes, S. (2006). Openability: producing design limits for consumer packaging. *Packaging Technology and Science*, *19*(4), 219–225. https://doi.org/10.1002/pts.725

Zizza, C. A., Ellison, K. J., & Wernette, C. M. (2009). Total Water Intakes of Community-Living Middle-Old and Oldest-Old Adults. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *64A*(4), 481–486. https://doi.org/10.1093/gerona/gln045

Appendices

Appendix A: Supplementary methods

Appendix B: Supplementary results

Appendix C: Journal requirements: *Australasian Journal of Ageing*

Appendix A: Supplementary Methods

A.1 Participant information sheet

Waitemata
District Health Board
Best Care for Everyone

Participant Information Sheet

Study Title: Assessment of hydration status in older adults

Locality: North Shore Hospital

Lead Investigator: Associate Professor Carol Wham
Nutrition and Dietetics
Massey University
027 6680058

You are invited to take part in a study to determine if you are consuming enough fluid from food and drinks (well hydrated) while you are in hospital. Whether or not you take part is your choice. If you don't want to take part, you don't have to give a reason, and it won't affect the care you receive. If you do want to take part now, but change your mind later, you can pull out of the study at any time.

This Participant Information Sheet will help you decide if you'd like to take part. It sets out why we are doing the study, what your participation would involve, what the benefits and risks to you might be, and what would happen after the study ends. We will go through this information with you and answer any questions you may have. You do not have to decide today whether or not you will participate in this study. Before you decide you may want to talk about the study with other people, such as family, whānau, friends, or healthcare providers. Feel free to do this.

If you agree to take part in this study, you will be asked to sign the Consent Form on the last page of this document. You will be given a copy of both the Participant Information Sheet and the Consent Form to keep.

This document is six pages long, including the Consent Form. Please make sure you have read and understood all the pages.

What is the purpose of the study?

The purpose of this study is to evaluate the adequacy of fluid provision and consumption in older adults in hospital. Whether you are sufficiently hydrated from fluids and foods consumed will be determined by a blood test (to measure serum osmolality). Dehydration of just a small amount of total body water can result in reduced ability to undertake everyday tasks. Problems associated with dehydration may include constipation, pressure sores, confusion, low blood pressure as well as prolonged illness and an increased length of stay in hospital. Older adults (≥ 65 years) are especially susceptible to dehydration due to age related changes.

As there are currently no reliable tests to find out if someone is dehydrated, we aim to create a reliable fluid assessment tool to measure consumption of water, milk and other drinks as well as from food.

A reliable hydration assessment tool is needed to improve hydration in hospitalised older adults and can be used in the future to identify older persons at risk of poor oral fluid intake. A reliable fluid assessment tool can also be used for further investigation and intervention in other hospitals throughout New Zealand.

This study is led by researchers within the department of Nutrition and Dietetics at Massey University in Albany in collaboration with the Waitemata DHB. The study will also lead to a master's qualification.

Additional Investigators are:

Teresa Stanbrook, Professional Leader for Dietitians and Clinical Leader for Dietetics Medical Health of Older People and Surgical and Ambulatory Services at Waitemata DHB

Rozanne Kruger, Associate Professor of Dietetics and Human Nutrition, Massey University Albany

Marilize Richter, Lecturer in Nutrition and Dietetics, Massey University Albany

Alexandra Smithers, Masters student in Nutrition and Dietetics, Massey University, Albany

Danika Pillay, Dietitian Research Assistant, Nutrition and Dietetics, Massey University Albany

What will my participation in the study involve?

You have been identified as a potential participant for this study because you are in the correct age group. If you consent you will be selected for this study. The study will include a total of about 220 participants. We acknowledge you may wish to discuss this project with your whanau before consenting.

If you agree to participate in the study the following will occur:

1. Once you have signed the consent form to participate in the study, you will be enrolled in the study.
2. We will then schedule a time for a researcher to meet with you to complete a short questionnaire about your thirst and fluid intake. This will take approximately 30 minutes at a time that is convenient for you. The researcher will observe and measure the fluids that are provided to you and consumed throughout the day from all drinks, food and snacks over a three day period. Ward staff will record this information during the night.

3. You will be having a blood test around the time your fluid intake is being assessed to measure your hydration status. Remaining blood will be destroyed and no sample will be stored.
4. This completes your study procedures.
5. You may withdraw from the study at any time.

What are the possible benefits and risks of this study?

It is possible that the blood test may detect that you are not sufficiently hydrated. If this happens you will be offered appropriate help and support by the Hospital team.

Confidentiality: What are my rights?

Results of this study will be presented at research meetings and submitted for publication to peer-reviewed journals. However, no material that could personally identify you will be used in any reports on this study. Consent forms will be kept in a locked filing cabinet in the Department of Nutrition and Dietetics at Massey University or will be stored on password-protected computers. Research data will be stored for a period of ten years after data collection is complete (as required by New Zealand law), at which time they will be destroyed. With your permission, non-identifiable data from this study may be used in future related studies, which have been given ethical approval from the Ethics Committee. Again no data that could personally identify you will be released or reported.

Results:

If requested, you will be offered copies of the publications that arise from this research. However, you should be aware that a significant delay may occur between completion of data collection and completion of the final report. Alternatively, or in addition, you can choose to have the results of the study discussed with you personally by the lead investigator.

Questions:

You may have a friend or whanau support to help you understand the risks and/or benefits of this study and any other explanation you may require.

Who do I contact for more information or if I have concerns?

If you have any questions, concerns or complaints about the study at any stage, you can contact:

Carol Wham, Associate Professor, Massey University, Albany

Telephone number 09 213 6644 or 027 6680058
Email c.a.wham@massey.ac.nz

If you want to talk to someone who isn't involved with the study, you can contact an independent health and disability advocate on:

Phone: 0800 555 050
Email: advocacy@hdc.org.nz

If you require Māori cultural support talk to your whānau in the first instance. Alternatively you may contact the administrator for He Kamaka Waiora (Māori Health Team) by telephoning 09 486 8900 ext 42324.

You can also contact the health and disability ethics committee (HDEC) that approved this study on:

Phone: 0800 4 ETHICS

Email: hdecs@moh.govt.nz

A.2 Participant consent form

CONSENT FORM

Waitemata District Health Board
Best Care for Everyone

If you need an interpreter, this can be provided.

Please sign to indicate you consent to the following

I have read, or have had read to me in my first language, and I understand the Participant Information Sheet.	
I have been given sufficient time to discuss with family/whānau or a friend when a decision is required and to consider whether or not to participate in this study.	
I have had the opportunity to use a legal representative, whanau/ family support or a friend to help me ask questions and understand the study.	
I am satisfied with the answers I have been given regarding the study and I have a copy of this consent form and information sheet.	
I understand that taking part in this study is voluntary (my choice) and that I may withdraw from the study at any time without this affecting my medical care.	
I consent to the research staff collecting and processing my information, including information about my health.	
If I decide to withdraw from the study, I agree that the information collected about me up to the point when I withdraw may continue to be processed.	
I consent to my GP or current provider being informed about my participation in the study and of any significant abnormal results obtained during the study.	

I agree to an approved auditor appointed by the New Zealand Health and Disability Ethic Committees, or any relevant regulatory authority or their approved representative reviewing my relevant medical records for the sole purpose of checking the accuracy of the information recorded for the study.	
I understand that my participation in this study is confidential and that no material, which could identify me personally, will be used in any reports on this study.	
I consent to have non-identifiable data collected from this study used in future related studies that have been approved by the Ethics Committee	
I know who to contact if I have any questions about the study in general.	
I understand my responsibilities as a study participant.	
I wish to receive a summary of the results from the study.	Yes ☐ No ☐

Declaration by participant:

I hereby consent to take part in this study.

Participant's name:

Signature: Date:

Declaration by member of research team:

I have given a verbal explanation of the research project to the participant, and have answered the participant's questions about it.

I believe that the participant understands the study and has given informed consent to participate.

Researcher's name:

Signature: Date:

A.3 Demographic Questionnaire

1. Which of these best describes your ethnicity?

NZ European	Maori	Pacific	Other (please specify)
1	2	3	4

Comments:

2. What is your current marital status?

Married/Partnered	Widowed	Divorced/Separated	Never married
1	2	3	4

Comments:

3. Who lives in your house/unit/apartment with you most of the time?

Living alone	Living with spouse only	Living with others
1	2	3

Comments:

4. What is your highest level of education?

Primary	Secondary	Tertiary/ Trade
1	2	3

Comments:

5. Do you receive any income in addition to your pension?

Pension only income	Pension plus other income
1	2

Comments:

6. Do you receive any regular subsidised support service?

Yes	No
1	2

Comments:

7. Do you usually need help with daily tasks like shopping, cleaning, cooking?

Yes	No
1	2

Comments:

8. What is your dental status?

Denate	Edentulous	Dental appliance
1	2	3

Comments:

9. Have you previously had any dietetic input?

Yes	No
1	2

Comments:

A.4 FAST

1. Have you been provided with a water jug?

Yes	No
1	2

Comments:

2. Can you pour yourself a glass of water? **(Observe)**

Yes	No
1	2

Comments:

3. Do hospital staff remove unfinished fluids with your meal tray at the end of meal times at all?

Yes	No
1	2

Comments:

4. How do you position yourself during meal and snack times? **(Ask patient to demonstrate)**

5. Are you interrupted by staff members at all during meal times?

Yes	No
1	2

Comments:

6. Are you encouraged drinking fluids throughout the day by the hospital staff, e.g. Nurses, doctors or catering assistants?

Yes	No
1	2

7. On a scale from 1 to 5, with 1 being not very important and 5 being very important, how important is it for you to drink fluids during the day?

Not important				Extremely important
1	2	3	4	5

Comments:

8. Why did you pick the number you did?

9. Do you require any assistance with drinking fluids e.g. using straws?

Yes	No
1	2

Comments:

10. Do you struggle to open the lids of any of the beverages? (If no skip to question 13)

Yes	No
1	2

Comments:

11. What lids do you struggle to open?

12. If you are struggling to open a product do you seek assistance or do you leave it?

Assistance sought	Leave it
1	2

Comments:

13. Do you have any difficulty swallowing fluids e.g. coughing, choking or pain? (If no skip to question 15)

Yes	No
1	2

Comments:

14. Which fluids are difficult for you to swallow?

15. At the moment do you feel as though you are currently constipated?

Yes	No
1	2

Comments:

16. Have you experienced any vomiting in the past three days? (If no skip to question 18)

Yes	No
1	2

Comments:

17. How many times have you vomited in the past three days?

18. Have you experienced any diarrhoea in the past three days? (If no skip to question 21)

Yes	No
1	2

Comments:

19. How many times have you experienced diarrhoea in the past three days?

20. Did you reduce your fluid intake at all to help manage your diarrhoea?

Yes	No
1	2

Comments:

21. Do you struggle with controlling your bladder after drinking large quantities of fluid? (If no skip to question 23)

Yes	No
1	2

Comments:

22. Do you specifically drink less to avoid the difficulty with controlling your bladder?

Yes	No
1	2

Comments:

3. Do you drink anything other than what is provided to you? (If no skip to question 25)

Yes	No
1	2

Comments:

24. Where do you source these beverages?

The vending machines at the hospital	The onsite cafe	Family	Friends
1	2	3	4

Comments:

25. Do you often feel thirsty?

Yes	No
1	2

Comments:

26. Do you only drink when you are thirsty?

Yes	No
1	2

Comment

27. At what point in the day do you feel most thirsty?

Morning	Midday	Afternoon	Evening
1	2	3	4

Comments:

A.5 FIAT

Fluid Intake Assessment Tool

Hydration Study 2018

NEXT

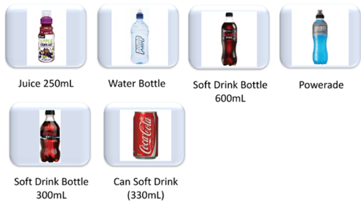
FIAT

- The FIAT tool used in combination with FIAT protocol will allow researchers to quantify fluids from high fluid foods and beverages.
- This tool is to be completed by the researcher.

NEXT

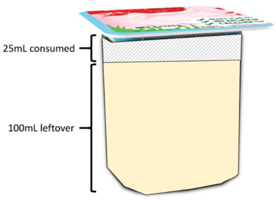
High fluid foods and drinks provided by North Shore Hospital

Other Beverages (Vending Machine / Cafeteria)



Main Menu

Yoghurt Pottle

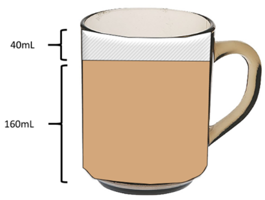


Main Menu

Pinto Juice

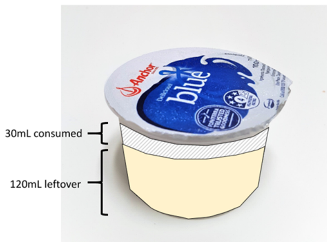
Main Menu

Coffee / Tea / Milo



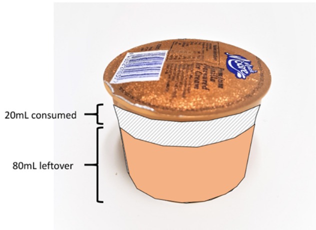
Main Menu

Milk



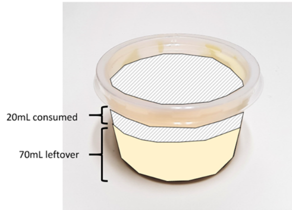
Main Menu

Ice-cream



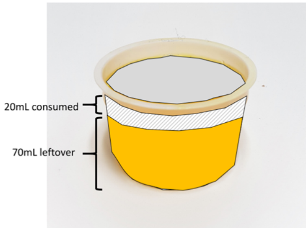
Main Menu

Custard



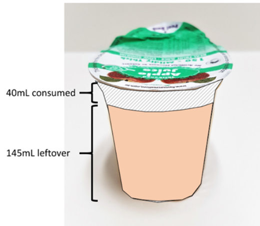
Main Menu

Jelly



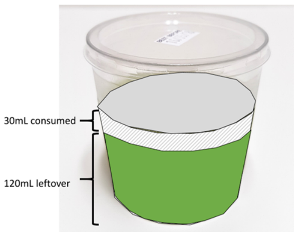
Main Menu

Thickened fluids



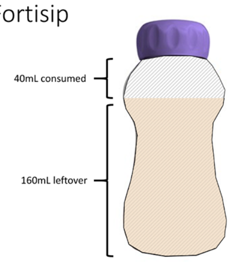
Main Menu

Kiwi crush juice



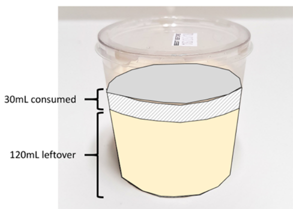
Main Menu

Fortisip



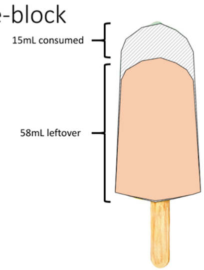
Main Menu

High protein drink



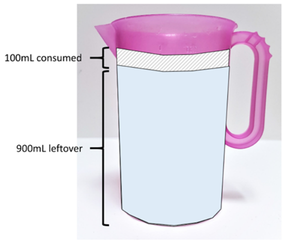
Main Menu

Ice-block



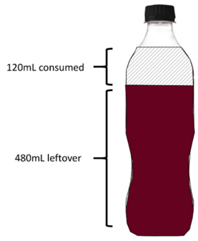
Main Menu

Pink water jug



Main Menu

Bottle of soft drink (600mL)

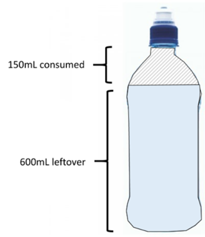


Main Menu

Juice (Hills Orchard Bottle, 250mL)

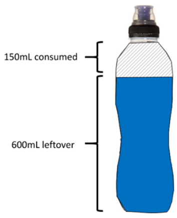
Main Menu

Water bottle



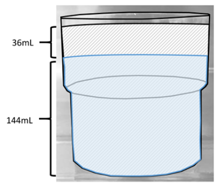
Main Menu

Powerade Sports Drink



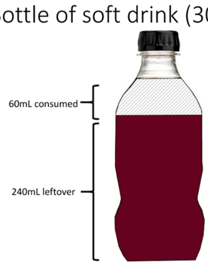
Main Menu

Plastic Cup



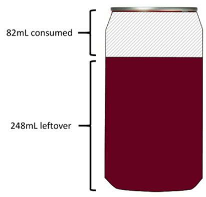
Main Menu

Bottle of soft drink (300mL)



Main Menu

Can of soft drink (330mL)



Main Menu

Soup Mug

Appendix B: Supplementary Results

Table 5.1: Factors affecting patient access to fluid and medication use by dehydrated and hydrated.

Participant characteristics		Total (n%)	Dehydrated ≥295 (n%)	Hydrated –≤295 (n%)	P-Value
Participants (n %)		45	24	21	
Provided with a water jug	Yes	44 (97.8)	24 (100)	20 (95)	.280
	No	1 (2.2)	0 (0)	1 (5)	
Able to pour water	Yes	42 (93.3)	24 (100)	18 (85.7)	.055
	No	3 (6.7)	0 (0)	3 (14.3)	
Hospital staff removing unfinished drinks	Yes	1 (2.2)	1 (4.2)	0 (0)	.344
	No	44 (97.8)	23 (95.8)	21 (100)	
Interrupted by staff during meal times	Yes	18 (40)	7 (29.2)	11 (52.4)	.113
	No	27 (60)	17 (70.8)	10 (47.6)	
Able to finish meal when interrupted	Yes	45 (100)	24 (100)	21 (100)	-
	No	0 (0)	0 (0)	0 (0)	
Fluid consumption encouraged	Yes	36 (80)	19 (79.2)	17 (81)	.881
	No	9 (20)	5 (20.8)	4 (19)	
Perceived importance of fluid intake	Not important to somewhat important	19 (42.2)	10 (41.7)	9 (42.9)	.936
	Important to very important	26 (57.8)	14 (58.3)	12 (57.1)	
Requires assistance when drinking	Yes (straws)	3 (6.7)	1 (4.2)	2 (9.5)	.472
	No	42 (93.3)	23 (95.8)	19 (90.5)	
Struggles to open hospital fluid lids	Yes	21 (46.7)	14 (58.3)	7 (33.3)	.094
	No	24 (53.3)	10 (41.7)	14 (66.7)	
Seeks assistance to open beverages	Yes	15 (33.3)	9 (37.5)	6 (28.6)	.283
	No	30 (66.7)	15 (62.5)	15 (71.4)	
Consumes beverages that are not provided by the hospital	Yes	14 (31.1)	8 (33.3)	6 (28.6)	.731
	No	31 (68.9)	16 (66.7)	15 (71.4)	
Difficulty swallowing	Yes	3 (6.7)	1 (4.2)	2 (9.5)	.472
	No	42 (93.3)	23 (95.8)	19 (90.5)	
Vomiting last 3 days	Yes	4 (8.9)	2 (8.3)	2 (9.5)	.889
	No	41 (91.1)	22 (91.7)	19 (90.5)	
Currently constipated	Yes	16 (35.6)	7 (29.2)	9 (43)	.338
	No	29 (64.4)	17 (70.8)	12 (57)	
Diarrhoea last 3 days	Yes	6 (13.3)	2 (8.3)	4 (19)	.292
	No	39 (86.7)	22 (91.7)	17 (81)	
Reduced fluid intake to manage diarhoea	Yes	2 (4.4)	1 (4.2)	1 (5)	.923
	No	43 (95.6)	23 (95.8)	20 (95)	
Difficulty controlling bladder	Yes	20 (44.4)	10 (41.7)	10 (47.6)	.688
	No	25 (55.6)	14 (58.3)	11 (52.4)	
Reduces fluid intake due to difficulty of controlling bladder	Yes	1 (2.2)	0 (0)	1 (5)	.280
	No	44 (97.8)	24 (100)	20 (95)	

Participant characteristics		Total (n%)	Dehydrated ≥295 (n%)	Hydrated –≤295 (n%)	P-Value
Only drink when thirsty	Yes	1 (2.2)	1 (4.2)	0 (0)	.344
	No	44 (97.8)	23 (95.8)	21 (100)	
Number of regular medications	5 or less	11 (25)	7 (30.4)	4 (19.1)	.657
	Between 6 and 10	25 (56.8)	13 (56.5)	12 (57.1)	
	10 or more	8 (18.2)	3 (13.1)	5 (23.8)	
Number of discharge medications	5 or less	10 (22.2)	4 (16.7)	6 (28.6)	.556
	Between 6 and 10	23 (51.1)	14 (58.3)	9 (42.8)	
	10 or more	12 (26.7)	6 (25)	6 (28.6)	
Discharged on new anti-hypertensive medications	Yes	8 (20.5)	5 (25)	3 (15.8)	.606
	No	31 (79.5)	15 (75)	16 (84.2)	
Discharged on new laxative medications	Yes	13 (28.9)	5 (20.8)	8 (38.1)	.202
	No	32 (71.1)	19 (79.2)	13 (61.9)	
Meets fluid requirements	Yes	6 (14)	2 (8.7)	4 (20)	.286
	No	37 (86)	21 (91.3)	16 (80)	

d/c: discharged.
Pearson's chi-square used to test for significance.

Appendix C: Journal Requirements: *Australasian Journal of Ageing*

See https://onlinelibrary.wiley.com/page/journal/17416612/homepage/forauthors.html#submit for more details.

Research Articles
Word limit: 3,000 words maximum (3,500 words for qualitative), excluding abstract and references.
Abstract: 150 words maximum; must be structured, under the sub-headings: Objective(s), Methods, Results, Conclusion.
References: Maximum of 30 references.
Figures/Tables: Total of no more than 5 figures and tables.
Description: Full-length reports of quality current research within any area of gerontology and geriatric medicine. All qualitative research articles must follow the COREQ guidelines and the COREQ checklist must be submitted.

Manuscript Style

Manuscripts should follow the style of the Vancouver agreement detailed in the International Committee of Medical Journal Editors' revised 'Uniform Requirements for Manuscripts Submitted to Biomedical Journals: Writing and Editing for Biomedical Publication', as presented at http://www.ICMJE.org/.

Note that this journal discourages the use of the pejorative terms "elderly" and "seniors". The terms "ageing" and "older people" are preferred.

Spelling. The journal uses Australian spelling and authors should therefore follow the latest edition of the Macquarie Dictionary. In particular, use "ageing" not "aging"

Abbreviations. In general, terms should not be abbreviated unless they are used repeatedly and the abbreviation is helpful to the reader. Initially use the word in full, followed by the abbreviation in parentheses. Thereafter use the abbreviation only.

Units. All measurements must be given in SI or SI-derived units. Please go to the Bureau International des Poids et Mesures (BIPM) website at http://www.bipm.fr for more information about SI units.

Decimal places. Guidance on the number of decimal places to use in reporting results is provided online.

Trade names. Chemical substances should be referred to by the generic name only. Trade names should not be used. Drugs should be referred to by their generic names. If proprietary drugs have been used in the study, refer to these by their generic name, mentioning the proprietary name, and the name and location of the manufacturer, in parentheses.

Parts of the Manuscript

The manuscript should be submitted in three separate files: title page; main text file; figures.

Title Page

The title page should contain:
(i) a short informative title that contains the major Medical Subject Headings (MeSH) compatible key words. The title should not contain abbreviations;
(ii) the full name of each author;
(iii) each author's institutional affiliations at which the work was carried out;
(iv) the full postal and email address, plus telephone number, of the author to whom correspondence about the manuscript should be sent;
(v) acknowledgements and a statement of conflicts of interest; and
(vi) the present address of any author, if different from that where the work was carried out, should be supplied in a footnote.

Main Text

As papers are double-blind peer reviewed the main text file should not include any information that might identify the authors.

The main text of the manuscript should be presented in the following order:

Title, abstract and MeSH compatible key words;
(ii) text, including the aims and objectives of the paper/study;
(iii) impact statement (see below);
(iv) references;
(v) tables (each table complete with title and footnotes
(vi) appendices; and
(vii) figure legends.

Figures and supporting information should be submitted as separate files.

Abstract and key words

Research articles, Brief reports and Reviews. Abstracts should be 150 words maximum and structured into sections under the sub-headings: Objective(s), Methods, Results, Conclusion. ***Innovation and Translation*.** Should be preceded by a short structured abstract of 150 words maximum, using the sub-headings: Objective(s), Methods, Results, Conclusion, where relevant. ***Other articles.*** Editorials and Invited Commentaries do not need an abstract. For Invited Articles, the need for an abstract will be advised at invitation.

Five key words, for the purposes of indexing, should be supplied below the abstract, in alphabetical order, and should be taken from those recommended by the US National Library of Medicine's Medical Subject Headings (MeSH) browser list at https://www.nlm.nih.gov/mesh/