

# Hydration and outcome in older patients admitted to hospital (The HOOP prospective cohort study)

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## Abstract

**Background:** older adults are susceptible to dehydration due to age-related pathophysiological changes. We aimed to investigate the prevalence of hyperosmolar dehydration (HD) in hospitalised older adults, aged  $\geq 65$  years, admitted as an emergency and to assess the impact on short-term and long-term outcome.

**Methods:** this prospective cohort study was performed on older adult participants who were admitted acutely to a large UK teaching hospital. Data collected included the Charlson comorbidity index (CCI), national early warning score (NEWS), Canadian Study of Health and Aging (CSHA) clinical frailty scale and Nutrition Risk Screening Tool (NRS) 2002. Admission bloods were used to measure serum osmolality. HD was defined as serum osmolality  $>300$  mOsmol/kg. Participants who were still in hospital 48 h after admission were reviewed, and the same measurements were repeated.

**Results:** a total of 200 participants were recruited at admission to hospital, 37% of whom were dehydrated. Of those dehydrated, 62% were still dehydrated when reviewed at 48 h after admission. Overall, 7% of the participants died in hospital, 79% of whom were dehydrated at admission ( $P = 0.001$ ). Cox regression analysis adjusted for age, gender, CCI, NEWS, CSHA and NRS demonstrated that participants dehydrated at admission were 6 times more likely to die in hospital than those euhydrated, hazards ratio (HR) 6.04 (1.64–22.25);  $P = 0.007$ .

**Conclusions:** HD is common in hospitalised older adults and is associated with poor outcome. Coordinated efforts are necessary to develop comprehensive hydration assessment tools to implement and monitor a real change in culture and attitude towards hydration in hospitalised older adults.

**Keywords:** hydration, older adult, hyperosmolar dehydration, medical emergency, complications, mortality, older people

## Introduction

Older adults are susceptible to dehydration due to the pathophysiological changes that occur with ageing [1]. Age-related increase in the thirst threshold results in a blunted sensation of thirst [1]. Renal senescence reduces the ability of the kidney to conserve water and concentrate urine [1], and glomerular filtration rate (GFR) can reduce by 50–63% from the age of 30–80

years [2]. The risk of dehydration is exacerbated by comorbidities, polypharmacy and physical and mental disability [1].

Hyperosmolar dehydration (HD), a state of water depletion, is common in community-dwelling older adults and has been linked with increased morbidity and mortality [3, 4]. Dehydration of as little as 2% of body weight, corresponding to  $\sim 3$ –5% reduction in total body water can result in impairment in physical and cognitive performances [5]. Some studies

have suggested associations between dehydration and cardiovascular, respiratory, renal and gastrointestinal disorders [6].

A review of over 10 million hospital records from a US healthcare provider demonstrated that over 17% of older people with a principal diagnosis of dehydration as per the ICD classification died within 30 days of hospital admission, with a 1-year mortality of 48% [7]. However, this study did not control for confounders such as age, co-morbidities, illness severity or frailty. Few studies have used objective markers of hydration status, such as serum osmolality, which is the main regulated variable in water balance and is widely seen as a reliable objective measure [8, 9]. HD is the most common form of dehydration and occurs when water loss is greater than salt loss. It has been reported in up to 60% of community-dwelling older adults [3, 4].

This study aimed to investigate the prevalence of HD in hospitalised adults aged  $\geq 65$  years, admitted as emergencies to a large UK teaching hospital, and to assess its impact on short-term and long-term outcomes.

## Methods

This prospective cohort study was conducted between 31 August 2012 and 30 April 2014 and included patients aged  $\geq 65$  years admitted to hospital as emergencies. The protocol was approved by the NHS Research Ethics Committee and was registered at <http://clinicaltrials.gov> (NCT01703715). The hospital has a standardised mortality rate in keeping with the national average and was described by the Care Quality Commission (CQC) as a 'good trust': safe, caring, effective, responsive and well-led [10, 11]. Patients were excluded if they were moribund, with terminal illness and a predicted life expectancy of  $< 3$  months. Patients were recruited, and consent was obtained in accordance with ethical recommendations.

Data collected from the participant, medical notes and/or relatives included demographics and cause of hospital admission as well as co-morbidities, which were used to calculate the Charlson comorbidity index (CCI) [12]. Bedsides, observations were used to calculate the national early warning score (NEWS) [13]. The Barthel activity of daily living index (ADL) score was calculated [14]. Cognitive function was assessed using the mini mental state examination (MMSE) [15]. The confusion assessment method (CAM) was also used to document delirium [16]. Frailty was assessed using the Canadian Study of Health and Aging clinical frailty scale (CSHA) [17]. Participants were also screened for malnutrition using the nutrition risk screening tool (NRS) 2002 [18]. Data were also collected on typical fluid consumption habits by asking participants to estimate the average number of cups of beverages consumed on a typical day.

Blood sampled at admission was used to measure serum osmolality (by freezing point depression), serum concentrations of sodium, potassium, urea and creatinine, eGFR and full blood count. In addition, 5 ml urine sample was collected where possible. HD was defined as serum osmolality  $> 300$  mOsmol/kg [19].

Participants who were still in hospital 48 h after admission were reviewed and the same measurements were repeated. Participants who had been discharged were not reviewed. Following discharge, length of hospital stay, discharge destination and mortality were recorded. All the study participants were followed up, using the hospital's electronic records which were reviewed at 30 days, 90 days and 12 months after admission.

## Statistical analysis

Statistical significance was determined using the  $\chi^2$  test, independent samples *t*-tests and Mann–Whitney *U* tests.

Risk estimates for mortality were assessed for in-hospital stay and at 30, 90 days and 1 year after admission using Cox regression modelling. Explanatory variables considered were age, gender, co-morbidities (CCI), illness severity (NEWS) frailty (CHSA) score and nutritional status (NRS 2002). NRS 2002 and CCI were calculated excluding age, as age was considered and accounted for separately in keeping with the methods of Charlson *et al.* [12]. Differences were considered significant at  $P < 0.05$ .

## Results

Two-hundred participants were recruited to the study after screening 1409 admissions. Reasons for non-inclusion included admission  $> 12$  h ago ( $n = 417$ ), severely ill/moribund/on end-of-life pathway ( $n = 298$ ) and refusal to participate ( $n = 494$ ). Blood samples were obtained from all participants at admission. Participants' characteristics at admission and at 48 h after admission are summarised in the Supplementary data, Table S1, available in *Age and Ageing* online.

## Hydration status

At admission, 69 (37%) participants presented with HD. Of those with HD, 44 (64%) were reviewed again at 48 h and 36 (82%) had a repeat serum osmolality measure. Twenty-two (61%) of these 36 were also dehydrated at 48 h. However, on review of the medical notes, dehydration was reported clinically by the medical team in only 15 (8%) and acute kidney injury (AKI) in 24 (12%) of all the cases.

There were no significant differences in the age, gender, co-morbidities, NEWS, nutritional status or MMSE scores (Table 1), although biochemical differences were demonstrated (Supplementary data, Table S2, available in *Age and Ageing* online) between those euhydrated and those dehydrated at admission to hospital.

## Hydration and outcome

Overall, 14 (7%) participants died in hospital, 11 (79%) of whom were dehydrated at admission ( $P = 0.001$ ). The 30-day mortality was greater in those dehydrated at admission than in those who were euhydrated [11 (16%) versus 5 (4%) ( $P = 0.01$ )]. Cox regression survival analysis adjusted for age,

**Table 1.** Descriptive statistics of patients recruited to the study at admission comparing euhydrated (serum osmolality  $\leq 300$  mOsmol/kg) and dehydrated patients (serum osmolality  $> 300$  mOsmol/kg)

	Euhydrated ( <i>n</i> = 118)	Dehydrated ( <i>n</i> = 69)	<i>P</i> value
Age, mean (SD)	82 (7)	81 (8)	0.86
Gender			
Male, <i>n</i> (%)	66 (56)	34 (49)	0.38
Female, <i>n</i> (%)	52 (44)	35 (51)	
Canadian study of health and aging (CSHA) scale, median (Q1, Q3)	4.0 (3, 5)	4 (3, 6)	0.29
Charlson co-morbidity index, median (Q1, Q3)	4 (2, 5)	4 (3, 5)	0.22
National early warning score, median (Q1, Q3)	1 (0, 2)	1 (1, 2)	0.658
Barthel activities of daily living index, mean (SD)	15.2 (5.2)	14.7 (5.7)	0.63
Cognitive assessment (MMSE), <sup>a</sup> mean (SD)	24.5 (5.9)	24.4 (6.6)	0.93
Cognitive assessment (MMSE), <sup>a</sup> % with delirium, <i>n</i> (%)	29 (29.3)	14 (28.0)	0.87
Confusion assessment method (CAM) score % with delirium, <i>n</i> (%)	38 (32.2)	27 (39.1)	0.34
Nutritional assessments (NRS 2002), <sup>b</sup> median (Q1, Q3)	1 (1, 4)	1 (1, 4)	0.578
Nutritional assessments (NRS 2002), <sup>b</sup> % at risk of malnutrition, <i>n</i> (%)	38 (35.8)	27 (41.5)	0.457
Weight (kg), <sup>c</sup> mean (SD)	68.4 (17.3)	75.3 (15.6)	<b>0.02</b>
Height (cm), <sup>c</sup> mean (SD)	165 (12)	165 (12)	0.76
Body mass index (BMI), <sup>c</sup> mean (SD)	25 (6)	27 (7)	0.06
Approximate average daily fluid consumption (ml), <sup>d</sup> mean (SD)	1,406 (558)	1,326 (540)	0.40
Fluid consumption in past 48 h <sup>d</sup>			
Unchanged, <i>n</i> (%)	59 (56)	39 (67)	0.22
Increased, <i>n</i> (%)	7 (7)	1 (2)	
Decreased, <i>n</i> (%)	40 (38)	18 (31)	
Source of admission			
Emergency department, <i>n</i> (%)	102 (86)	61 (88)	0.70
General practitioner referral, <i>n</i> (%)	16 (14)	8 (12)	
Residence prior to admission			
Home, <i>n</i> (%)	103 (87)	59 (86)	0.73
Community care, <i>n</i> (%)	15 (13)	10 (15)	
Clinical diagnosis			
Dehydration	9 (8)	6 (9)	0.33
Acute kidney injury	6 (5)	15 (22)	<b>&lt;0.001</b>

Dehydrated refers to HD (serum osmolality  $> 300$  mOsmol/kg).

<sup>a</sup>MMSE—mini mental state examination. Results available in 159 study participants at admission 99 euhydrated and 50 dehydrated.

<sup>b</sup>NRS 2002—nutrition risk screen tool 2002. Results available in 184 study participants at admission 110 euhydrated and 62 dehydrated.

<sup>c</sup>Weight, height and BMI measurements available in 161 study participants at admission: 100 euhydrated and 51 dehydrated.

<sup>d</sup>Average fluid consumption based on the assumption that each cup of fluid consumed amounts to  $\sim 200$  ml of fluid. Data available in 176 study participants at admission: 106 euhydrated and 58 dehydrated.

A total of 187 (94%) had serum osmolality measured. One hundred and sixteen (58%) participants were reviewed at 48 h after admission: 110 (95%) of these underwent venous blood sampling, and 95 (86%) had serum osmolality measured. Admission and 48 h serum osmolality measures were available for 92 (46%) participants.

Bold signifies a statistically significant value.

gender, co-morbidity, NEWS, frailty and nutritional status demonstrated that participants dehydrated at admission to hospital were at greater risk of in-hospital mortality than those euhydrated at admission (Table 2).

The median (Q1, Q3) length of hospital stay between those euhydrated and those dehydrated at admission, 4 (1,11) versus 5 (1,11) days,  $P = 0.73$ .

## Discussion

This study has demonstrated that when using serum osmolality as a marker of hydration, HD was present in over a third of older adults admitted to hospital as medical emergencies, and nearly two-thirds of those remained dehydrated 48 h later.

HD was associated with 6 times greater risk of in-hospital mortality compared with those euhydrated, independent of

key confounders such as age, gender, co-morbidities (CCI), illness severity (NEWS) and risk of malnutrition. These findings are consistent with those from a previous study [7]. Difficulty in recognising and, therefore, treating dehydration is underpinned by the finding that nearly a quarter of those with HD at admission were also diagnosed with AKI by the medical team during the hospital stay. The 2009 UK National Confidential Enquiry into Patient Death highlighted that  $\sim 12,000$  deaths could be prevented annually by treating the ‘avoidable’ causes of AKI such as dehydration [20].

Dehydration in older hospitalised patients may be a major concern for patient safety and could also contribute to a significant public health burden with high cost implications [7]. However, the true costs are difficult to quantify as dehydration is often underdiagnosed.

This study demonstrated that there were few differences in some of the clinical features typically associated with dehydration between dehydrated and euhydrated participants.

Table 2. Hydration status and outcome

Mortality <sup>a</sup>	Euhydrated (n = 118)	Dehydrated (n = 69)	P-value	Unadjusted HR (95% CI)	P-value <sup>b</sup>	Adjusted <sup>c</sup> HR (95% CI)	P-value <sup>b</sup>	Euhydrated to euhydrated (n = 46)	Euhydrated to dehydrated (n = 14)	Dehydrated to euhydrated (n = 12)	Dehydrated to dehydrated (n = 20)	P-value
In-hospital, n (%)	3 (3)	11 (16)	0.001	6.76 (1.89–24.23)	0.003	6.04 (1.64–22.25)	0.007	2 (4)	1 (7)	0 (0)	5 (25)	0.03
30 days, n (%)	5 (4)	11 (16)	0.01	4.07 (1.41–11.41)	0.009	3.52 (1.19–10.41)	0.024	3 (7)	1 (7)	0 (0)	5 (25)	0.07
90 days, n (%)	16 (14)	16 (23)	0.09	1.91 (0.954–3.82)	0.068	1.82 (0.90–3.65)	0.095	7 (15)	3 (21)	2 (17)	8 (40)	0.15
1-year, n (%)	28 (24)	19 (28)	0.57	1.20 (0.67–2.13)	0.542	1.14 (0.64–2.03)	0.655	13 (28)	4 (29)	3 (25)	9 (45)	0.53

Dehydrated refers to HD (serum osmolality >300 mOsmol/kg).

<sup>a</sup>Mortality rate after admission to hospital.

<sup>b</sup>Comparing with those euhydrated at admission.

<sup>c</sup>Model adjusted for age, gender, illness severity: national early warning score (NEWS), co-morbidities: Charlson comorbidity index (CCI), frailty: Canadian Study of Health and Aging (CSHA) and nutrition: nutrition risk screening (NRS) 2002.

Clinical manifestations of dehydration include dry skin and reduced skin turgor, but these lack sensitivity and specificity due to other age-related skin changes. Other features of HD include dizziness, weakness and apathy, all of which may erroneously be attributed to other causes or simply ascribed to the ageing process, meaning that dehydration may not be recognised [21].

Some limitations should be considered when interpreting these results of this single-centre study. The use of serum osmolality to assess hydration status does not necessarily represent the overall 24-h fluid balance, but rather the hydration status at the time of blood sampling given that serum osmolality is tightly regulated.

HD may be a manifestation of disease severity, and an increase in mortality would, therefore, be expected. However, we have attempted to account for confounders including age, frailty, nutritional status and cause of admission and co-morbidities using the CCI and illness severity using NEWS. It is also important to note that although dehydration may be unavoidable in some unwell older adults, there is a clear need to improve hydration and nutrition care in older adults.

Given that hydration and nutrition are the hallmarks of compassionate care, there is clear room for improvement, with findings from our present study suggesting a need for further investigation and intervention in both community and hospital settings. Coordinated efforts are necessary to develop comprehensive guidelines and hydration assessment tools as well as to implement and monitor a real change in culture and attitude towards hydration in hospitalised older adults.

### Key points

- HD may be present in over a third of older adults admitted to hospital as medical emergencies.
- Dehydration may persist even 48 h after admission.
- HD at admission is associated with significant increase in mortality, even after correcting for confounders.

### Authors' contributions

A.M.E.-S. and D.N.L. contributed to design and conduct of the study, data analysis and interpretation, review and approval of the manuscript. P.W. contributed to conduct of the study, data analysis and interpretation, review and approval of the manuscript. K.R.N. contributed to data analysis and interpretation, review and approval of the manuscript. R.J.M. and O.L. contributed to design, data interpretation, review and approval of the manuscript. O.S. contributed to design and conduct of the study, data interpretation, review and approval of the manuscript.

### Supplementary data

Supplementary data mentioned in the text are available to subscribers in *Age and Ageing* online.

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## Conflicts of interest

A.M.E.-S., K.R.N. and O.S. have no conflicts of interest to declare. P.W. has received research funding from the food and beverage industry. R.J.M. is Chair of the Science Advisory Board of the European Hydration Institute: he has received research funding and speaker's honoraria from the food and beverage industry. D.N.L. has no direct conflicts of interest to declare, but has received unrestricted research funding and speaker's honoraria from Fresenius Kabi, BBraun and Baxter Healthcare for unrelated work. O.L. has no direct conflict of interest to declare but serves as Advisor for Nutricia, a medical nutrition company, and has received speaker's honoraria from Fresenius Kabi, BBraun, Nutricia and Merck for unrelated work.

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