

## STUDI E RICERCHE

# Development of a screening tool to assess dehydration in hospitalized older population: a diagnostic, observational study

Sviluppo di uno strumento di screening per valutare la disidratazione nella popolazione anziana ospedalizzata: uno studio diagnostico, osservazionale.

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## ABSTRACT

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**INTRODUCTION:** dehydration is a frequent condition in older people and is associated with an increased risk of negative health outcomes. In order to adopt strategies to prevent complications, an early recognition of this status is of primary importance. For this reason, a comprehensive assessment tool to monitor hydration status in older people could be useful.

**AIM:** to develop a screening tool to detect dehydration in older people in hospital settings.

**METHODS:** this is a diagnostic, observational study. The new tool is a modified version of the Geriatric Dehydration Screening Tool (GDST), integrated with seven questions and two clinical signs based on updated literature. We tested the new tool with people aged 65 or over. We used as reference standard serum osmolarity. Cronbach's alpha was used to measure the tool's reliability and subscales. We calculated the Area Under ROC Curve (AUC) to choose the cut-off that gave the best balance between sensibility and specificity.

**RESULTS:** 127 patients participated in the study. The reliability of the new GDST was acceptable (Cronbach's alpha 0.63). The diagnostic accuracy, measured with AUC analysis, was  $0.83 \pm 0.04$ ,  $p < 0.0001$  95% CI 0.72-0.87. The best cut-off value was 6 and showed a sensibility of 78%, specificity of 70%. Tongue dryness proved to be the most significant clinical sign associated with poor hydration status (AUC 0.78;  $p < 0.0001$ , 95% CI 0.69-0.86).

**CONCLUSION:** The new GDST presented an acceptable reliability and diagnostic accuracy that increased with the assessment of some items, such as tongue dryness. This is the first screening tool that presents a promising cut-off value.

**KEYWORDS:** dehydration, aged, screening, inpatients, sensibility, specificity.

## RIASSUNTO

**INTRODUZIONE:** La disidratazione è una condizione comune nella persona anziana ed è associata a numerosi rischi per la salute e ad esiti negativi. È importante il precoce riconoscimento di questa condizione, al fine di adottare strategie per prevenirne le complicanze. Per questa ragione è necessario sviluppare strumenti validati per valutare il rischio di disidratazione nelle persone anziane.

**OBIETTIVO:** sviluppare uno strumento di screening per individuare la disidratazione nelle persone anziane ospedalizzate.

**METODO:** il disegno di studio adottato è di tipo diagnostico, osservazionale. Lo strumento creato è basato sul "Geriatric Dehydration Screening Tool" (GDST), che è stato modificato aggiungendo sette domande e due segni clinici, basati sulla letteratura recente. Lo strumento è stato testato in persone con un'età maggiore o uguale a 65 anni ospedalizzate. Come reference standard è stata usata l'osmolarità sierica. È stato calcolato l'alfa di Cronbach per testare l'affidabilità della consistenza interna dello strumento e delle sue sotto scale. È stata calcolata l'area sotto la curva di ROC (AUC) per individuare il cut-off che dava il miglior bilanciamento tra sensibilità e specificità.

**RISULTATI:** 127 pazienti hanno partecipato allo studio. L'affidabilità dello strumento è risultata discreta (Alfa di Cronbach=0.63). L'accuratezza diagnostica, misurata con l'AUC era  $0.83 \pm 0.04$ ,  $p < 0.0001$ , 95% IC 0.72-0.87. Il cut-off migliore è risultato essere il valore 6, con una sensibilità del 78% e specificità 70%. La secchezza della lingua è risultato essere il segno clinico più associato con uno stato di disidratazione (AUC 0.78,  $p < 0.0001$  95%CI 0.69-0.86).

**CONCLUSIONI:** il nuovo GDST ha dimostrato un'accettabile affidabilità e accuratezza diagnostica che aumenta con la valutazione di alcuni items, come la secchezza della lingua. Questo è il primo strumento che presenta un valore di cut-off promettente.

**PAROLE CHIAVE:** disidratazione, anziano, screening, pazienti ospedalizzati, sensibilità, specificità.

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## INTRODUCTION

Water-loss (or hypertonic) dehydration is a common condition in older people and it results from drinking too little fluid (Hooper, et al., 2015). Insufficient fluid intake causes an increase of serum osmolality (raised concentration of minerals and small molecules in serum) (Hooper et al., 2014). The negative outcomes associated with this condition can be: falls, fractures, heart disease, confusion, delirium, heat stress, constipation, kidney failure, pressure ulcers, poor wound healing, suboptimal rehabilitation outcomes, infections, seizures, drug toxicity, and reduced quality of life (Begum & Johnson, 2010; Hooper, et al., 2014; Hooper, et al., 2015; Rowat, et al., 2011; Scarpa, 2012; Wakefield, et al., 2008; Wotton et al., 2009; Wu et al., 2010). Furthermore patients with dehydration have an higher risk of disabilities and death post hospital discharge (Rowat et al., 2011).

The prevalence of dehydration among hospitalized older people is very high: a prospective cohort study, on older adults who were admitted acutely to a large U.K. hospital, showed that 37% of 200 participants were dehydrated (El-Sharkawy, et al., 2015). Another study showed similar results: 36% (927) participants were dehydrated on the day of the admission or the day after, while 62% (1606) patients were dehydrated at some point during their stay (Rowat, et al., 2011). Older people living in nursing homes are considered at high risk of dehydration as well (Mentes, 2006).

Dehydration is the result of insufficient fluid intake and can be consequent to an alteration of thirst mechanisms or fluid loss from the intestinal and respiratory tracts. The use of diuretics can lead to dehydration too. The risk of dehydration induced by acute or chronic diseases is increased in older people because of the reduced capacity to maintain a proper fluid balance. Lower muscle mass, reduced kidney function, physical and cognitive disabilities, blunted thirst, and polytherapy are recognized as main risk factors for dehydration in older people (Hooper, et al., 2014).

For these reasons, coordinated efforts are necessary to develop comprehensive assessment tool to monitor hydration in hospitalised older adults (El-Sharkawy et al., 2015). We need to develop a pathway of screening to detect early stage dehydration in older patients in order to correct it promptly (Hooper et al., 2014).

Presently, no standardized clinical dehydration assessment method exists and there are relatively few papers investigating hydration status. Through a review of current literature, only two evaluation scales have been found. The first tool is the Dehydration Risk Appraisal Checklist created by Mentes and Wang in 2011 to assess the risk of dehydration in hospitalized older people. It is composed by items regarding health status, medica-

tions, drinking habits and laboratory parameters. The risk of dehydration is correlated to the numbers of factors present. Since this tool doesn't have a scoring, it becomes difficult to obtain an objective evaluation.

The second tool is the Geriatric Dehydration Screening Tool (GDST) created by Vivanti, et al. (2010), later reviewed by Rodrigues et al., (2015). It consists of three parts: the first one investigates social-demographic data and clinical issues regarding the drug intake of the patients. The second part takes into consideration four clinical data: body weight, skin turgor, blood pressure, measured both in supine and orthostatic position, tongue hydration. The third part is composed by eleven questions requiring dichotomous answers. The questions are divided as follows: five questions are about hydration habits and provide the "Hydration Score". Five questions investigate factors such as pain and impaired mobility which can have an impact on the hydration capacity and the provide "Pain Score" (Rodrigues, et al., 2015).

The last question is: "Do you generally drink during meals?" and is not included in the previous groups (Vivanti, et al., 2010).

The GDST lacks a comprehensive score but provides health professionals with all the elements required for a correct diagnosis of poor hydration state.

We decided to develop a new tool with the aim to detect and assess dehydration among older people in clinical care settings. The GDST was chosen as model because, compared to the tool propose by Mentes and Wang., (2011), does not require laboratory parameters, and thus its use is also feasible outside hospital settings. In order to obtain objective evaluation a comprehensive score and a cut-off were developed in the new tool. Diagnostic accuracy of the modified dehydration screening tool was assessed against the best available reference standard for water-loss dehydration: serum osmolality (cut-off  $\geq 296$  mOsm/l).

## METHODS

### Study Design and Sample

A diagnostic, observational design was used in the present study (Bossuyt, et al., 2015, Polit & Tatano Beck, 2014) Data collection was undertaken between September and October 2016. This study enrolled hospitalized Italian older people recruited in the Teaching Hospital Luigi Sacco of Milan (ASST Fatebenefratelli-Sacco), selected based on convenience sampling.

The inclusion criteria were:

- Patients  $\geq 65$  years of age at the moment of the interviews;
- Patients hospitalized in Department of Urgency Medicine, Oncology, Gastroenterology, Depart-

tment of Physiopathology Medicine, Department of General Medicine, Department of Subacute Care and Department of Orthopaedics;

- Complete blood tests: Urea, Glucose, Sodium, Potassium reported not more than 48 hours before the observation;
- Patients without impaired cognitive capacity.

The wards chosen were the ones with the highest probability to find older people.

### Data Collection

After obtaining the consent from the participants, the researchers proceeded with data collection.

Before screening assessment, blood samples results of the participants were collected, including sodium, potassium, urea and glucose in order to calculate osmolarity.

The first researcher collected participant's administrative information (initial of name and surname, day of admission and day of data collection, number of medical recorder, ward and admission diagnosis). Afterwards socio-demographic (gender, age and educational level) and clinical data (drug's assumption and previously diagnosed health conditions) were collected.

The drugs affecting renal function and, as a consequence, altering hydration status such as diuretics, laxatives and psychotropic drugs (anxiolytics and antipsychotics) were recording. It was also recorded whether the patient used to take more than four drugs a day, as literature reports that this variable is associated with a major risk of dehydration (Mentes, 2006).

In order to test, inter-rater reliability two researchers observed the hydration of the tongue independently.

### Reference standard

The reference standard used to assess dehydration was serum osmolarity (Hooper, 2014), which is an indirect estimate of serum osmolality (Siervo, et al., 2014). Glucose, urea and electrolyte concentrations are the laboratory parameters used to calculate serum osmolarity. Two different validated equations were used to calculate serum osmolarity. The best serum osmolarity equation, sensitivity (79%) and specificity (89%), is:

$$1.86 \times (\text{Na}^+ + \text{K}^+) + 1.15 \times \text{glucose} + \text{urea} + 14$$

(all in mmol/L) cut-off  $\geq 296$  mmol/L (dehydration).

This equation can be used to predict hydration status in frail older people (as a first-stage screening) or to estimate hydration status in population studies (Siervo et Al., 2014). Subjects are classified as dehydrated or not dehydrated according to the results of the serum osmolarity's equation.

The second equation is specific for patients with chronic renal failure: it leads to reliable results despite

the altered urea values which are a common condition for these patients.

$$(1.86 \times \text{Na}^+ + \text{K}^+) + \text{glucose} + \text{Urea} + 9$$

(Trepiccione, et al., 2014).

### New Geriatric Dehydration Screening Tool (NGDST)

The New Geriatric Dehydration Screening Tool (NGDST) is based on the Vivanti et al., (2010) questionnaire and on the later revised version elaborated by Rodrigues et al., (2015). Forward and back translation procedure and content validity evaluation by experts were used to cross-cultural validation in Italian of the tool in a previous study (Messina, et al., 2017).

The NGDST consists of three sections.

The first section investigates social-demographic data (age, gender, educational level), drugs, comorbidity. The second section includes the following physical signs: hydration of the tongue, body weight, axillary hydration, axillary moisture and Body Mass Index (BMI).

Compared to the GDST in the Vivanti, et al., (2010) and Rodrigues et al., (2015). versions, some changes were made. The only parameters included were body weight and tongue hydration. Blood pressure measured both supine and in orthostatic position was removed because of it is very difficult to assess due to the limited mobility of older people.

Skin turgor was removed too, since the physiological decrease of skin turgor and elasticity in older people does not allow a correct evaluation. Furthermore, a recent study demonstrated that these two clinical signs are not definitely associated with a chronic poor hydration status because human body tries to adapt himself to this condition and some symptoms, such as changes in blood pressure, that are found in acute conditions, are missing in chronic dehydration (Messina, et al., 2017).

The assessment of axillary hydration and moisture, have recognized as dehydration signs by recent studies (Hooper, et al., 2015; Kinoshita, et al., 2013) was added.

Axillary examination was performed for both axillae through palpation with the second to fifth fingers. The axillary moisture was measured through TC Skin Tester, a bipolar device for the biomedical assessment of the skin hydration level. This instrument, based on Analysis of Bio-Electric Impedance (ABEI) at high frequency bipolar (50 kHz), allows the assessment of the levels of water in the epidermis. An electrode is applied at the centre of the axilla in the supine position and it automatically measures the impedance of the stratum corneal in term of percentage in 9 seconds. The measurement accuracy is considered under 7% approximately (Kinoshita, et al., 2013).

Weight is classified in two categories: < 50 kg for

women, < 70 kg for men are likely to be risk factors for dehydration according to Vivanti et al., (2010). Body mass index was recorded in two categories:  $\leq 27.0$  or  $> 27$  kg/m<sup>2</sup>, according to the WHO report where it is stated that the most favourable BMI for adults aged 60 years or older are 21.0-27.0 kg/m<sup>2</sup> for men and 23.0-27.0 kg/m<sup>2</sup> for women (Rodrigues et al., 2015). For the assessment of tongue dryness, the researcher asked older people to show the tongue in order to evaluate its characteristics.

The questionnaire is composed by 18 questions: eleven questions were taken from the GDST in the Vivanti, et al. (2010) and Rodrigues et al., (2015). version. Six questions regarding the risk of dehydration in older people were added, in accordance with two recent systematic reviews of the Joanna Briggs Institute (Long, 2015; Singht, 2015).

The questions added were the following: "In the last 24 hours, did you have muscle cramps?", "In the last two weeks, did you feel dizzy?", "In the last 24 hours, did you notice concentrated dark-yellow urine?", "When you speak, do you feel a dry mouth and sticky saliva?", "In the last 2 weeks, did you feel irritable?" "Which are your ways of hydration?".

In order to assess the daily water supply, a finally question was included: "How many glasses do you drink in a day?". This question refers to all kinds of beverages (water, tea, fruit juice, milk). The answers have been classified according to the Mini Nutritional Assessment, as "less than three glasses", "three to five glasses", "more than five glasses". One glass corresponds to 200 ml. of liquid. We used this classification for daily liquid intake because MNA is the reference standard for nutritional status assessment in older people (Bauer, et al., 2008; Cereda, et al., 2016).

All items except two were dichotomous (yes or no). One point was assigned if the answer suggested dehydration, zero point if the answer showed a normal hydration condition.

Three options were given for "tongue hydration": hydrate tongue (score=0), dehydrated tongue (score=1), very dehydrated tongue (score=2). Also the item regarding the autonomy of the patient in drinking was classified with three answers: "can drink by his/herself" (score=0), "needs just a support (i.e. pouring water) (score=1), "needs assistance" (score=2).

### Statistical Analysis

Statistical analysis was performed using Statistical Package for the Social Sciences SPSS (version 22.0). Descriptive statistics were generated for the age and gender characteristics of the participants. Means and

standard deviations summarized continuously variables, categorical variables were summarized as counts and percentages.

Cronbach's alpha was calculated to assess the internal consistency validity of the NGDST; Cohen's kappa coefficient was used to assess the inter-rater reliability of the tongue's hydration stage.

Receiver Operating Characteristic (ROC) curve analysis was used to measure the diagnostic accuracy of the new tool and of the most promising items by means of the Area Under the ROC Curve (AUC). Sensibility (SE), specificity (SP), positive predictive value (PPV) and negative predictive value (NPV) were calculated. We analysed the AUC coordinates in order to choose the best cut-off value of the new screening tool, in terms of sensibility and specificity (Sedgwick, 2015). To assess concurrent validity, the correlation among the NGDST score and osmolality, osmolality and fluid intake was evaluated using the Spearman's rho coefficient. We calculated the Odds Ratio (OR) of three variables, with corresponding 95% Confidence Interval (CI) and significance, that literature reports to be associated with dehydration in older population. The three variables are female gender, polypharmacology and dry tongue. A p-value <0.05 was considered significant (Kimear & Gray, 2006).

### Ethical considerations

The study was conducted in accordance with the Declaration of Helsinki and the protocol was approved by the Director of Nursing Service and Director of Medical service of the Teaching Hospital Luigi Sacco of Milan (ASST Fatebenefratelli-Sacco). Details about the study were verbally explained to the participants, including the aims of the research, the methods and procedures employed, and the contact details for any necessary support. Subjects were also informed that participation was voluntary and that they could withdraw at any given time. A written consent was obtained from all participants before the enrolment in the study.

## RESULTS

A sample of 127 patients aged 65 years or older participated to the study. Socio-demographic data, presented in Table 1, showed that the mean length of stay was five days ( $\pm 4.5$ ); the participants were more women (53.5%) than men (46.5%), with a mean age of  $81 \pm 7.5$  years. The majority of participants reported a primary education level (40.9%), presented a polypharmacy, such as diabetes, hypertension or other chronic disease, and a large proportion (74%) took at least four drugs per day. According to osmolality levels, forty-seven patients (60%) were dehydrated.



Table 1. Participants characteristic

Participants Characteristics (N=127)	Mean	±SD§
Age (years)	81	7.5
LOS* (days)	5	4.5
Gender	Frequency	%
Female	68	53.5
Male	59	46.5
Education level		
No schooling	12	9.4
Primary education	52	40.9
Middle education	31	24.5
Secondary education	22	17.3
Higher education	10	7.9
Polypathology (≥3)	73	58.4
Polytherapy (≥4)	94	74
Hydration Status (Osmolarity)		
Dehydrated (≥296 mmol/l)	60	47.2
Normal hydration status (<296 mmol/l)	67	52.8

\* Length of Stay; §Standard Deviation

The flow of the participant through the study is showed in Figure 1.

### Internal consistency Reliability - Cronbach's alpha

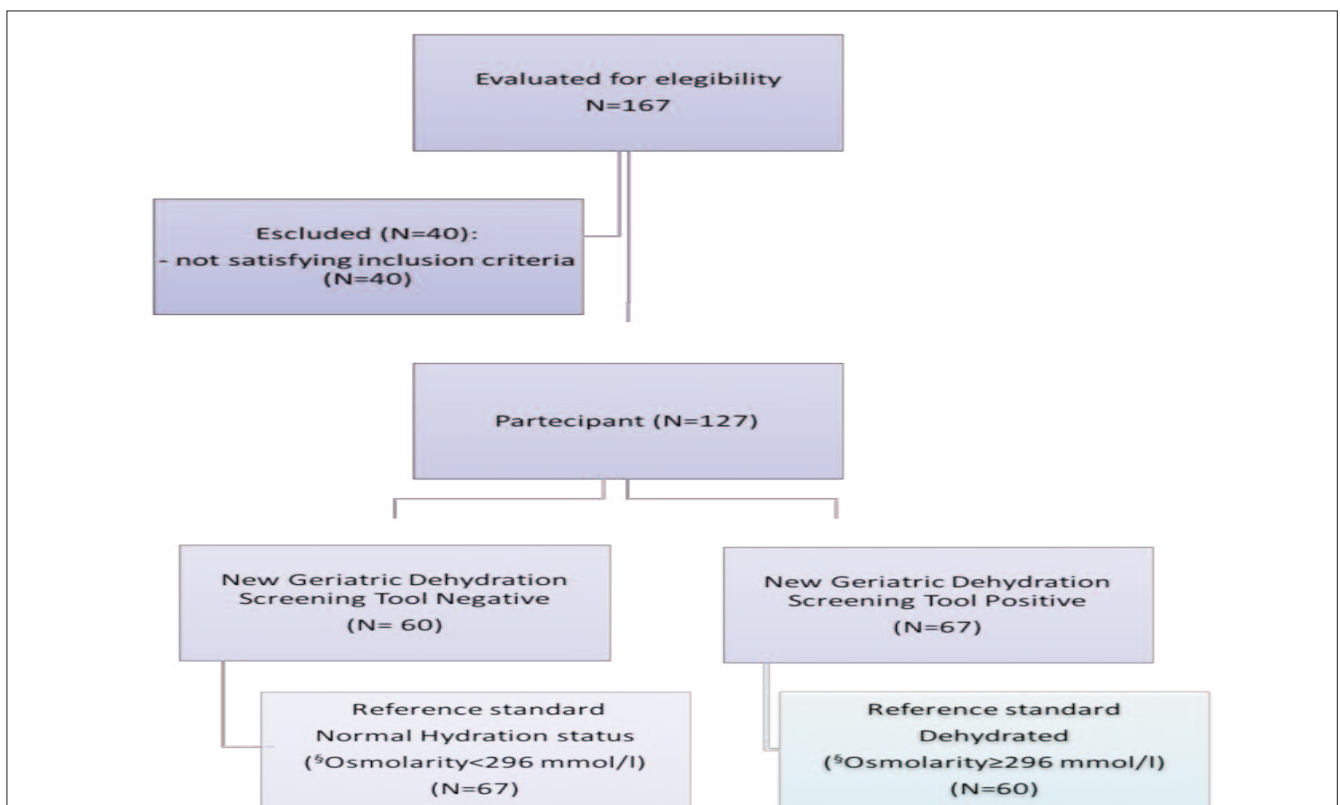
Cronbach's alpha (0.63) of the 22 items showed a discreet reliability.

### Cronbach's alpha subscales

A recent validation analysis, performed by Rodrigues et al. (2015), showed the existence of two distinct factors in the GDST, which were named "Pain Score" (Cronbach's alpha=0.66) and "Hydration Score" (Cronbach's alpha=0.58). We examined Cronbach's alpha of these two factors, considering the same items used by Rodrigues, et al. (2015). The "Pain Score" was composed by five items: "Do you have difficulty moving your shoulders, arms or hands?"; "In the last two weeks, did pain interfere with your daily activities?"; "In the past 2 weeks, did you have problems with pain of any kind?"; "In the past two weeks, did you drop something?"; "In the past week, did you frequently have headaches?"

The "Hydration Score" was composed by five items: "Do you ever feel thirsty?", "Did you feel thirsty yesterday?", "Do you like to drink water?", "If you have several beverage available, do you usually choose water?" and "Are you concerned about being well hydrated?". We obtain an alpha of 0.66 for the "Pain Score" and 0.49 for the "Hydration Score". The item "Did you usually drink at meals?" was excluded from both scores

Figure. 1 STARD diagram to report flow of participants through the study \* (Bossuyt et al., 2015)



\* Considering a cut-off of six; §We were always able to calculate Osmolarity in the patients included, because patients without complete blood tests were excluded.

by a previous validation study because it showed a loading below 0.4 for the two factors (Rodrigues, et al., 2015).

### Concurrent validity

The NGDST score and the serum osmolarity showed a moderate, positive and statically significant correlation ( $r_s=0.47$ ,  $p<0.0001$ ). A higher score of the tool is therefore related to a higher osmolarity value. The insufficient fluid intake was related to a poor hydration status: the results showed a significant but moderate correlation ( $r_s =0.389$ ,  $p< 0.0001$ ).

### Diagnostic accuracy - ROC curve

A significant diagnostic accuracy was measured through ROC curve between the NGDST and the presence of poor hydration status (osmolarity  $\geq 296$  mOsm/L):

The AUC of the overall tool was 0.83,  $p< 0.0001$ , 95% CI 0.72-0.87.

The most promising clinical parameter associated with dehydration was the assessment of tongue dryness (Table 2).

It showed the best AUC, compared to other items (AUC 0.78, CI 95% 0.69-0.86). The agreement on tongue dryness assessment performed by the two researchers was high, although they hadn't done a specific training before their observations (Cohen's kappa= 0.77,  $p< 0.0001$ ).

Table 2: AUC of the new geriatric dehydration screening tools /(NGDTS) and other terms

	AUC*	p-value	CI 95%	
New Geriatric Dehydration Screening Tool (NGDST)	0.83	<0.0001	0.72	0.87
Tongue dryness	0.78	<0.0001	0.69	0.86
Axillary Hydration	0.68	<0.0001	0.59	0.78
Axillary moisture	0.72	<0.0001	0.62	0.81
Dry mouth perception	0.73	<0.0001	0.64	0.82

\*AUC=Area Under Curve.

In Figure 2 are reported the AUC of the overall scale and other items.

Figure 2: AUC of the new geriatric dehydration screening tools (NGDTS) and other items

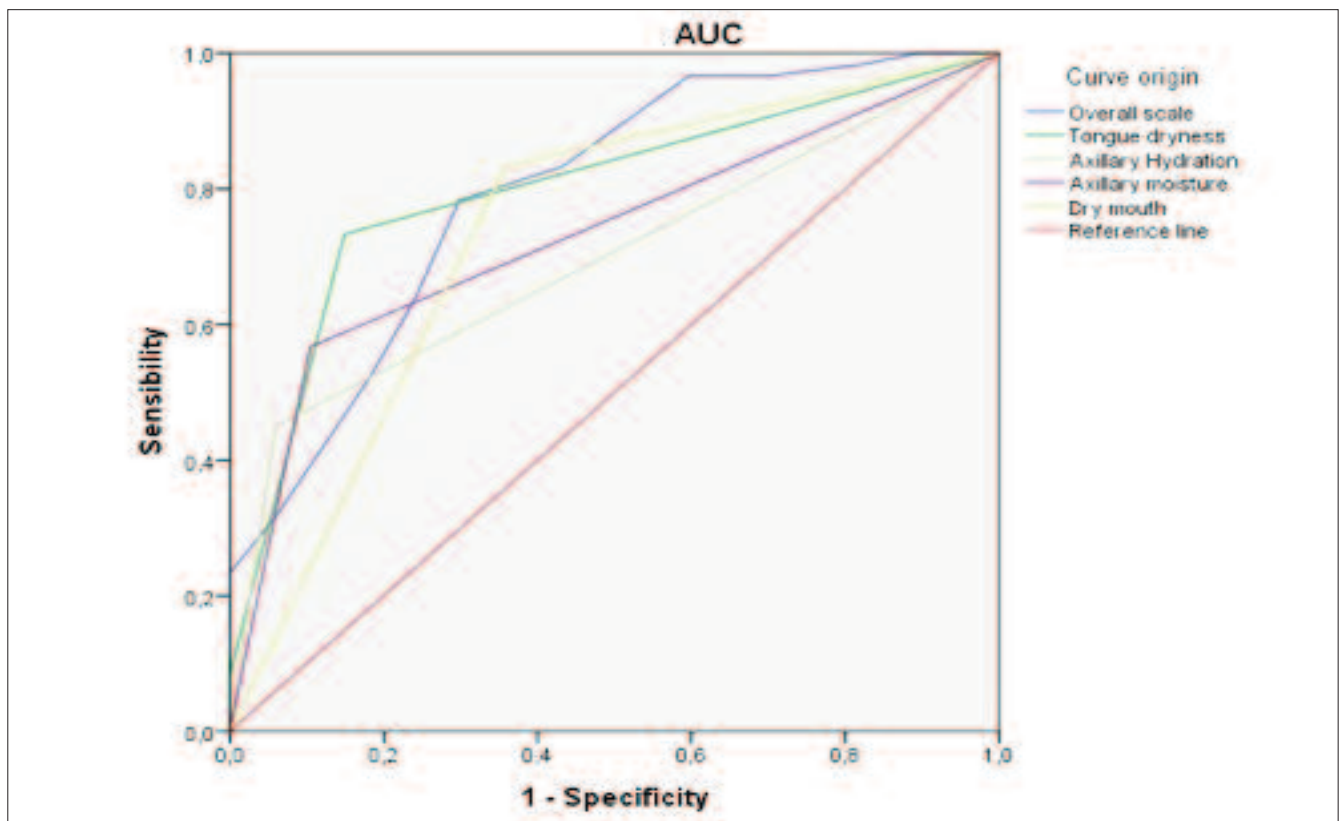


Table 3. Comparison between cut-off 5 and cut-off 6

	SE	95% CI	SP	95% CI	PPV+	95% CI	NPV-	95% CI	P-value
Cut-off 5	0.83	0.74-0.93	0.57	0.45-0.69	0.63	0.53-0.74	0.79	0.68-0.91	<0.0001
Cut-off 6	0.78	0.68-0.89	0.70	0.59-0.81	0.70	0.59-0.81	0.78	0.68-0.89	<0.0001

SE=sensibility; SP=specificity; PPV= positive predictive value; NPV= negative predictive value.

Table 4. Odds ratios of dehydration risk

Variables	ODDS RATIO	95% CI	p-value
Female gender	1.02	0.51 2.04	0.96
Poly-pharmacology	2.18	0.95 4.90	0.063
Dry tongue	12.51	5.28 29.64	0.0001

### Sensibility and specificity- cut-off 5 and 6

In order to get the best sensibility (SE) and specificity (SP), positive (PPV) and negative (NPV) predictive value of the NGDST, we have chosen a cut-off value of 6 through the examination of ROC curve coordinates because it showed the best balance between sensibility and specificity compared with a Cut-off of 5, the other more promising cut off (Table 3).

### Risks of dehydration

In this study only dry tongue among the three variables assessed showed a significant association with an increasing risk to be dehydrated (Table 4).

## DISCUSSION

This study aimed to develop a clinical practical screening tool to help health professionals to identify hospitalized dehydrated older people. It takes less than fifteen minutes and it is easy to use by anyone. The results seem to be promising. Although Cronbach's Alpha should be higher than 0.70, the reliability of the New Geriatric Dehydration Screening Tool is discreet (Cronbach's Alpha 0.63). A recent validation analysis by Rodrigues, et al., (2015), showed the existence of two distinct factors in the GDST, which were named "Pain Score" and "Hydration Score".

In this study the result of Cronbach's Alpha in "Pain Score" is similar to the one obtained by Rodrigues et al. (2015) (Cronbach's alpha=0.66) whereas the one referring the "Hydration Score" is lower than the one worked out by Rodrigues, et al., (2015) (Cronbach's alpha=0.49). The fact that Rodrigues enrolled not only hospitalized patients but also people living in a community may explain this difference.

The total score of the new Geriatric Dehydration Screening Tool was significantly and moderately correlated to serum osmolarity, which was taken as reference standard to diagnose dehydration as the analysis of the Spearman's rho correlation coefficient points out ( $r_s=0.47$ ,  $p<0.0001$ ). This correlation highlights that an higher score correspond to an increasing serum osmolarity, therefore, to a higher risk of dehydration, showing in this way a good concurrent validity of the tool.

This study is the first that, through AUC analysis, allowed to choose the best cut-off value. The older patients with a cut-off value higher than six were considered dehydrated with a sensibility of 78%, specificity of 70%, positive predict value of 70% and negative predict value of 78%. The diagnostic accuracy, expressed by the AUC, could be considered satisfactory (AUC=0.83; ES  $\pm$  0.04,  $p<0.0001$  95% CI 0.72-0.87). We chose a cut off of six because it gives the best balance between sensibility and specificity. Further exams could be performed for the individuals wrongly classified as dehydrated (Sedgwick, 2015).

The hydration of the tongue is, among the clinical signs examined, the one with higher sensibility and specificity. The study carried out by Vivanti, et al., (2010) supports this result. In the current study, the analysis of sensibility and specificity of this clinical sign showed an AUC larger than the one obtained from the other clinical signs (AUC=0.78,  $p<0.0001$ , CI 95% 0.69-0.86).

Furthermore the agreement between the two researchers resulted high, even without a specific training or protocols (Cohen's kappa=0.77). According to Vivanti, et al., (2010) the reliability could increase by 90% after a training. As far as axillary hydration and the percentage of axillary moisture are concerned, the study conducted by Kinoshita, et al., (2013) showed a

higher sensibility and specificity compared to the current study. These differences could result from the fact that two different markers to assess the hydration status were used in the two studies.

In this study we examined also three risk factors that were showed as probably correlated to dehydration in literature.

The dehydration risks analysis in this study demonstrated that the female gender is not correlated with an increased risk of dehydration in older population, although the literature shows controversial results (Mentes, 2006; Vivanti, et al., 2008; Wotton, et al., 2009). In this study the odds ratio of female gender is 1.02 and this parameter is not statistically significant ( $p=0.96$ ), moreover, in the 95% CI, it is included the unit (0.51-2.04) that leads to consider the null hypothesis. Older people taking more than four drugs per day seem to have a double risk of dehydration (OR 2.18) but the null hypothesis (95% CI 0.95-4.9) must be taken into consideration: the small sample size probably affects this result. On the other hand the presence of a dry tongue increases considerably the risk of dehydration; for this reason the tongue assessment can be considered a good alternative to perform with older people with cognitive impairments who cannot answer the questionnaire.

Although the prevalence of dehydrated people is higher in non-clinical settings and perhaps the use of a specific tool for assessing dehydration is more useful in those contexts, we decided to perform this research in a clinical setting because we needed recent blood tests to calculate osmolality. As the participants' hospital stay was short, the hypothesis that a number of patients were dehydrated at home as well should be taken into consideration. For this reason, it will be worthy to test the tool also in non-clinical settings.

### Limitations

We recruited a convenience and small sample considering the high number of items examined. For this reason our findings need to be replicated with a larger sample size and in prospective studies. For the same reason, we were not able to perform factor analysis in order to bring out the items of the scale which are most significant for dehydration assessment and to evaluate the consistency of tool's dimensions and subscales.

Another limit of the study is the fact that we didn't use a validate tool to assess patients cognitive impairment. Anyway, patients who gave incoherent answers were excluded. In the future it will be useful adopt validate tools like Mini-Mental State Examination (MMSE). It was difficult to establish clinical validity because of the lack of verified standard for clinical

dehydration assessment. Furthermore, the assessment of tongue dryness could have been influenced by the effect of drinking shortly before the observation.

### CONCLUSION

This study contributed to the development of a clinical tool for assessing dehydration among hospitalized older patients. Although further studies are needed to improve this new screening tool, promising findings have been achieved. The cut-off value allowed the assessment of dehydrated older people with a considerable sensibility and specificity; a score higher than six should alert health professionals of an increased risk of dehydration and should prompt them to monitor the patient and adopt strategies to assure a proper hydration.

Some parameters examined were associated with dehydration and were useful to screen hypo-hydrated older people. Tongue dryness was the best item in terms of sensibility and specificity. Because of the high prevalence of dehydrated people, this study underlines the need for health professionals to have a screening tool to assess the older people at risk of dehydration, in order to adopt the best evidence care to restore a normal hydration status.

Validation of the new tool in larger populations of older people and prospective studies are required. This tool requires the patient's collaboration: for this reason it can only be used with patients without cognitive impairment. It will be interesting to test in future research if the clinical signs (tongue dryness, axillar moisture, axillar hydration) are sufficient to reach a good sensitivity and specificity in order to use it also with people with cognitive impairment.

### Conflicts of interest statement

The authors declare no conflict of interest.

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