Taste Perception in Hemato-Oncology Patients: A Cross-sectional Design

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INTRODUCTION

Cancer is one of the most life threatening diseases and its prevalence is still growing [1]. Chemotherapy is often prescribed as cancer treatment, sometimes in combination with radiotherapy, immunotherapy, or stem cell transplantation (SCT). Many patients suffer from chemotherapy-induced adverse events or side effects, such as taste alterations.

Taste includes the sensation of sour, salt, sweet, bitter and umami, detected trough taste buds, mainly in the tongue. If taste is perceived different compared with an earlier taste experience, an alteration or change of taste (dysgeusia) has occurred. Taste alterations negatively influence nutritional status, weight, and quality of life (QOL) [2-6]. In a systematic review, Hovan et.al. (2010) described a weighted prevalence of 56%-76% of taste alterations in oncology patients receiving chemotherapy. Breast and gynaecologic cancer patients, for example, mainly experience taste changes or alterations 30 days after their first chemotherapy regimen [7]. Goldberg et al. (2005) validated the ChemoSensory Questionnaire (CSQ) to evaluate taste and smell function in patients with head and neck cancer [8].

In general, becoming older (>50) significantly leads to sensory loss because of declining number of taste buds.[9] Smoking is considered to influence taste[10], and smell and taste are related as well [8, 9, 11].

In cancer patients, taste change can be a result of the type of cancer itself [11] or the chemotherapy regimen prescribed [4, 10, 11]. Radiation in the head and neck area is known to influence taste alterations as well [12]. In breast and gynaecologic cancer patients, taste seemed most related with appetite loss and fatigue [7].

Few indications are available about blood values, possibly related to taste. In several studies, Vitamin A [13, 14], B12 [10, 15], Vitamin D [16], and Zinc [17] were mentioned. It is, however, unclear if associations between taste alterations and these blood values exist in hemato-oncology patients, whereas these studies were conducted with animals or in oncology patients. Patients, who experience taste changes, notice that certain food tastes like iron [4]. In Medline, no studies according to a possible correlation between iron blood level (Fe) and taste alterations were published.

Other factors that might influence taste, could be oral mucositis, a complication of chemotherapy which damages the mouth environment [18]; the Body Mass Index (BMI), according to an expert opinion at a congress for oncology nurses in 2011; and a decreased magnesium blood level, observed in practice at the hematology ward.

Although few studies explored taste changes in cancer patients, the majority of these studies only included oncology patients, while hematology patients complain a lot about taste changes as well. In practice, nurses and other healthcare workers experience lack of knowledge about how to inform and support patients who experience these taste changes. It is unclear how many patients with hematological malignancies experience an altered taste function, or how severe they score taste alterations using a questionnaire like the CSQ.

For all factors described above (Age, Smoking, Type of Cancer, Chemotherapy regimen, Fatigue, Appetite Loss, Smell, Zinc, Vitamin A, Vitamin B12, Vitamin D, Magnesium, Fe, BMI and Oral Mucositis), insufficient evidence is available about a possible relation with taste changes, especially in hemato-oncology patients. Regarding the influence of taste changes on nutritional status, weight and QOL, more research was needed about factors that are associated with taste changes.

Problem statement

Although, in practice, many hemato-oncology patients complain about taste alterations, nurses and other health care workers experience lack of knowledge according to this subject, and evidence is insufficient. More research was needed to gain evidence based knowledge according to all factors described above and to improve the information towards hemato-oncology patients receiving chemotherapy.

Aim

This study was conducted to explore prevalence and severity of taste alterations, and associated or predictive factors. The aim of this study was to improve the knowledge of nurses and other health care workers according to taste alterations in hemato-oncology patients receiving chemotherapy. This enables them to give evidence based information towards patients who suffer from taste alterations.

Research questions

1. What is the *prevalence* and *severity* of taste alterations in hemato-oncology patients receiving chemotherapy?
2. Are Type of cancer, Type of chemotherapy, Body Mass Index (BMI), Iron (Fe), Vitamin A, Vitamin B12, Vitamin D, Zinc, Magnesium, Smell, Oral Mucositis, Fatigue, Appetite loss, Age, and Smoking *associated* with taste alterations in hemato-oncology patients receiving chemotherapy?
3. Which of the 15 factors mentioned above, can be identified to *predict* taste alterations in hemato-oncology patients receiving chemotherapy?

METHODS

For this study, a cross-sectional design was used, this is suitable to explore the prevalence and severity of taste alterations at one moment in time [19]. The study was approved by a Medical Ethical Committee and conducted in March, April and May 2012 in a University Medical Center (UMC) in the Netherlands.

Patients who visited the hematology ward, were manually screened for eligibility by the investigators. Patients were included if: older than 18, diagnosed with a hemato-oncologic disease, received chemotherapy in 6 weeks prior to participation in this study, and having blood drawn regularly. Patients were excluded if they had received surgery or radiotherapy in the head and neck area, or Total Body Irradiation (TBI).

Potential eligible patients were informed by their specialist. After written informed consent, the requested blood samples were added to the patients lab form for the day of participation. At that day, the patient also received the questionnaires, and body measurements were completed. The investigators checked if all questions were answered.

Chemosensory Questionnaire (CSQ)

The CSQ is developed and validated to measure smell and taste function in cancer patients[8]. The CSQ was translated to Dutch and back to the original language by a professional translating office. The Dutch version has not been validated; therefore Cronbach's Alpha was measured, to determine the internal consistency. Both scales (smell and taste) have 4 questions, with a minimum score of 4 and maximum score of 20. Goldberg describes that a higher score indicates better function.

To determine the prevalence of taste alterations, the Total taste score on the CSQ was divided in 2 categories. Whereas 12 is the sum of the (neutral) "sometimes" scores, the cut-off point was set at 12. A score of 4-12 was classified as presence of taste alterations and a score of 13-20 as no presence of taste alterations. For severity, all scores on the taste scale were used, whereas this gives insight in perception of taste alterations by the participants.

Blood samples

Blood samples were taken by qualified personnel, according to protocols of the UMC. The requested blood levels were determined by the Clinical Chemical department of the UMC. Three tubes were needed: A Heparin Gel tube (4ml) for *Magnesium* and *Fe(N)* (Colorimetric, Modular P), a Gold Serum Gel tube (7ml) for *Vitamin A* (HPLC/UV, Waters Alliance and Perkin-Elmer UV detector), *Vitamin B12* (LIA, Architect) and *Vitamin D 25 OH* (RIA after

extraction) and a MB tube for metals (7ml) for *Zinc* (AAS, AA 800) [20]. The investigators collected results from a software system used by the UMC.

To categorise lab results, lower and upper limits (determined by the UMC) were used: Vitamin A: 'Low' (<1.2), 'Normal' (1.2-3.0) and 'High' (>3.0); Vitamin D: 'Low' (<25), 'Normal' (25-150) and 'High' (>150); Zinc: 'Low' (<11), 'Normal' (11-19) and 'High' (>19); Magnesium: 'Low' (<.70), 'Normal' (.70-1.00) and 'High' (>1.00); Iron (Fe): 'Low' (<11), 'Normal' (11-32) and 'High' (>32). For Vitamin B12, no reference value was available in the UMC. However, a cut-off point of 150 is described by Raymakers (2005); a lower value than 150 means absolute Vitamin B12 deficiency[21].

Quality of Life Questionnaire (QLQ-C30)

The validated Dutch version of the Quality of Life Questionnaire (QLQ-C30) was used [22]. This questionnaire contains 28 questions with 4-item-scale and two questions with 7-item scale. Patients completed the whole questionnaire, as recommended by the EORTC QoL Group and EORTC QoL Unit [23]. Question 13 (appetite loss) and 18 (fatigue) were used. The EORTC scoring manual was used for statistical analysis [24].

Oral Mucositis Nursing Instrument (OMNI)

Oral mucositis was scored by the OMNI [18]. The Dutch version is validated and contains five items with a minimum score of 0 and maximum score of 14. The investigators were trained by a nurse practitioner of the hematology ward to perform the scoring.

Body Mass Index (BMI)

BMI was calculated by dividing body weight (kilograms) by squared length (meters) and categorised in 'Low' (<18,5), 'Normal' (18,5-25) and 'High' (>25). Length was measured barefoot with a stadiometer on the ward. Weight was measured with a weighting scale of the ward, while patients were wearing light clothing and no shoes. The weighting scales were calibrated once a year. If patients were too ill or tired, weight and length were asked.

Weight loss

To determine the percentage of weight loss in the past month and past six months prior to participation, patients were asked their weight "one month ago" and "six months" ago.

Socio-demographic and clinical characteristics

Socio-demographic questions were asked, to describe the participants of this study thoroughly according to generalizability. Nationality, home situation, education and smoking habits were asked using a small questionnaire, developed for this study. Age, sex, type of

cancer and chemotherapy regimen, were gathered by the investigators through status research.

Statistical methods

All data were collected in Statistical Package for Social Sciences (SPSS), version 19. Missing data were excluded from analysis. Descriptive statistics were used to describe socio-demographic and clinical characteristics and prevalence and severity of taste alterations. Total taste score on CSQ was recoded into a dichotomous variable: 'No taste alterations' versus 'Taste alterations'. Univariate binary logistic regression analysis was used to determine the association between Total taste score and 15 factors: Age, Smoking, Type of Cancer, Chemotherapy regimen, Fatigue, Appetite Loss, Smell, Zinc, Vitamin A, Vitamin B12, Vitamin D, Magnesium, Fe, BMI and Oral Mucositis. Statistical significance was set at P<.05. Factors with P<.10 were entered in multivariate logistic regression analysis, using the step forward method. Variables with P>.05 were removed.

Whereas a weighted prevalence of 56%-76% of taste alterations in oncology patients receiving chemotherapy was described, the expected prevalence for this study was set at 66% (P = 0.66), with 95% confidence interval (Z = 1.96), precision of 10% (d = 0.10). By using the formula for calculating sample size for prevalence studies[25]: $n = \frac{Z^2\ P(1-P)}{d^2}$, 87 patients were needed.

RESULTS

Figure shows that 180 patients were screened for eligibility. Many patients received TBI before participation, or did not receive chemotherapy. Reasons for not willing to participate were: "feeling too ill", "already having enough issues to deal with", or "already participating in other studies". Eventually 45 patients completed participation and were analysed.

(Figure. Flow diagram)

For % weight loss, one case was excluded from analysis whereas data were missing according to weight 'one month ago' and 'six months ago'. Some blood level results were not known yet at the moment of analysis. Excluded from analysis were: 1 patient for Vitamin A (2.2%), 3 for Vitamin D (6.6%), 10 for Zinc (22.2%), 2 for Fe (4.4%). Further, no data were missing.

(Table 1. Socio-demographic and clinical characteristics)

Socio-demographic and clinical characteristics

Table 1 shows overall characteristics of all participants. Overall, 10 different hemato-oncologic malignancies were diagnosed, and 22 different types of chemotherapy regimens were administered. Only the most frequent diagnoses ($n \geq 5$) and regimens ($n > 5$) were used to determine associations with taste alteration.

(Table 2. Prevalence & Table 3. Severity)

Prevalence & severity of taste alterations

All participants completed the Dutch version of the CSQ. Cronbach's Alpha was determined for both taste (.673) and smell (.696). Table 2 shows that 44.4% of the patients had a total CSQ score below 13. This means that almost half of the patients experienced taste alterations. "Table 3. Severity" shows the frequency of different scores for each question about taste. Nobody answered "never" to the question whether food tasted good, while on the other hand 11.1% always had a bothering sense of taste, 6.7% always found food tasting bland, and 4.4% always had a bad taste in their mouth.

Univariate associations with taste alterations

Associations between taste alterations and factors, with P-value P<.10, are shown in Table 4. For each factor, the odds ratio (OR), 95% Confidence Interval (95%CI) and P-value are given. While only 2 patients had 'Low' Fe and only 1 patient had 'Low' BMI, these variables were dichotomised into 'High' versus 'Low/Normal'. Vitamin D was dichotomised into 'Low' and 'Normal/High', whereas no patients had 'High' Vitamin D. Non-significant results are shown in the Appendix.

(Table 4. Associations with taste alterations)

Smell, Iron (Fe), high Body Mass Index (BMI), low Vitamin D, Hodgkin Lymphoma, Bleomycine and Procarbazine were significantly associated with taste alterations (P<.05). Cytarabine and Vitamin B12 were almost significant (P<.10).

Regarding the seven patients who received Bleomycine and Procarbazine, all of them were diagnosed with Hodgkin lymphoma (HL). This explains the fact that the odds ratio, 95%CI and p-value of HL are the same as well. Therefore Bleomycine and Procarbazine were not entered in the multivariate model.

Multivariate associations with taste alterations

Fe, Smell, BMI, Hodgkin Lymphoma, Vitamin D, Vitamin B12 and Cytarabine were manually entered into the model. This resulted in the multivariate model as presented in Table 5. The prediction model with Fe and Low vitamin D, also showed P-values < .05, but a combination of Fe, BMI and Low Vitamin D did not improve the model. This means that patients with high Fe blood level AND high BMI, significantly have greater odds to experience taste alterations, as well as patients with high Fe AND Low Vitamin D.

(Table 5. Multivariate model for taste alterations)

DISCUSSION

This study explored the prevalence and severity of taste alterations among hemato-oncology patients receiving chemotherapy and associations with other factors. Almost half of the patients had an altered taste function. Taste is significantly associated with smell, Hodgkin lymphoma, Bleomycine and Procarbazine, Fe, low Vitamin D and high BMI. High Fe level AND High BMI are identified as independent predictors for taste alterations.

A prevalence of 44.4% is lower than the prevalence of 56%-76% in oncology patients. It is unclear if hemato-oncology patients experience less taste alterations than oncology patients. Only 6 patients had a Total taste score between 17 and 20, meaning better taste function. Therefore, the prevalence of taste alterations in this study could be an underestimation, whereas a cut-off point of 12 was used.

Bleomycine and Procarbazine are part of the BEACOPP treatment, which all seven patients with Hodgkin Lymphoma received. BEACOPP also includes Etoposide, Doxorubicine, Cyclophosphamide, Vincristine, and Prednisolone. This suggests that patients with Hodgkin lymphoma and treatment with BEACOPP significantly will experience taste alterations. It is however unclear whether receiving Procarbazine or Bleomycine plays a role, or Prednisolone, or the combination of all regimens.

Although patients describe an iron taste after receiving chemotherapy, this study is unique, determining an association between taste alterations and high Fe blood level. As seen in practice, Fe can also be increased by receiving blood transfusions. Here the question arises whether patients received transfusions before participation in this study.

Maes et al. (2004) described a deficiency in vitamins (A, B12) as possible cause for dysgeusia [10]. According to the Dutch Food Center, Vitamin B12 is important for the nervous

system. Taste is a sensation that occurs trough taste buds and nerves[9]. Only one German article describes the correlation between vitamin B12 and taste [15]. Several studies with animals showed correlation between Vitamin A deficiency and altered appetite or taste [13, 14]. Vitamin A is correlated with vision, as well as impaired taste responses. Russel (1980) also described taste impairments due to Vitamin A deficiency in alcoholism and liver cirrhosis [26]. However, in our study, no significant univariate association was found for both Vitamin A and Vitamin B12.

Fink (2011) described Vitamin D as cofactor in altered taste in a case report [16]. In contrast, a comment on this article mentioned that evidence for this statement is poor [27]. In this study a significant association was found. Moreover, high BMI and low Vitamin D were independently associated with taste alterations in the multivariate model.

Regarding BMI, the dosage of chemotherapy regimen should be taken in consideration as well. In practice, dosage for each patient is calculated by using length and weight. Logically, this means that patients with greater length or weight, will receive a higher dosage of chemotherapy. It is unclear whether a higher dosage enlarges the risk of toxicity, which means influencing the severity of side effects like taste alterations.

A limitation in this study was the risk of bias according to weight. To determine BMI and percentage weight loss, body weight often was asked instead of measured, because patients were tired or ill. It was not possible to prevent this risk.

Although this study was conducted in a small study group, this study shows great results. As far as known, this is the first study that describes a significant association between taste alterations and Fe in hemato-oncology patients. It provides useful information considering taste alterations in hemato-oncology patients, contributing to evidence based information for nurses and other health care workers.

CONCLUSION

This study shows that almost half of the hemato-oncology patients receiving chemotherapy experience an altered taste function. Smell, high Fe blood level, low Vitamin D, high BMI, Hodgkin lymphoma, and receiving Bleomycine or Procarbazine are significantly associated with taste alterations. High Fe and High BMI were independently associated with taste alterations. Regarding the high prevalence, more attention for chemotherapy-induced tasted alterations in hemato-oncology patients is needed, especially in patients with high BMI and high Fe.

RECOMMENDATIONS

For nurses and other health care workers, first of all, it is important that they inform patients about the possible occurrence of chemotherapy-induced taste alterations. Second, special attention is needed for:

- Patients with high Fe AND high BMI
- Patients with high Fe AND low Vitamin D
- Patients with Hodgkin Lymphoma receiving BEACOPP

For future studies, it is recommended to use a prospective cohort design with multiple measurements in time. Also the amount of blood transfusions and dosage of chemotherapy need to be investigated and blood levels of interest should be determined before receiving chemotherapy. Whereas almost 100% of the patients answered “Yes” to the question if they find research about taste alterations important, it is absolutely necessary to conduct more studies in the future.

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FIGURES AND TABLES (1)

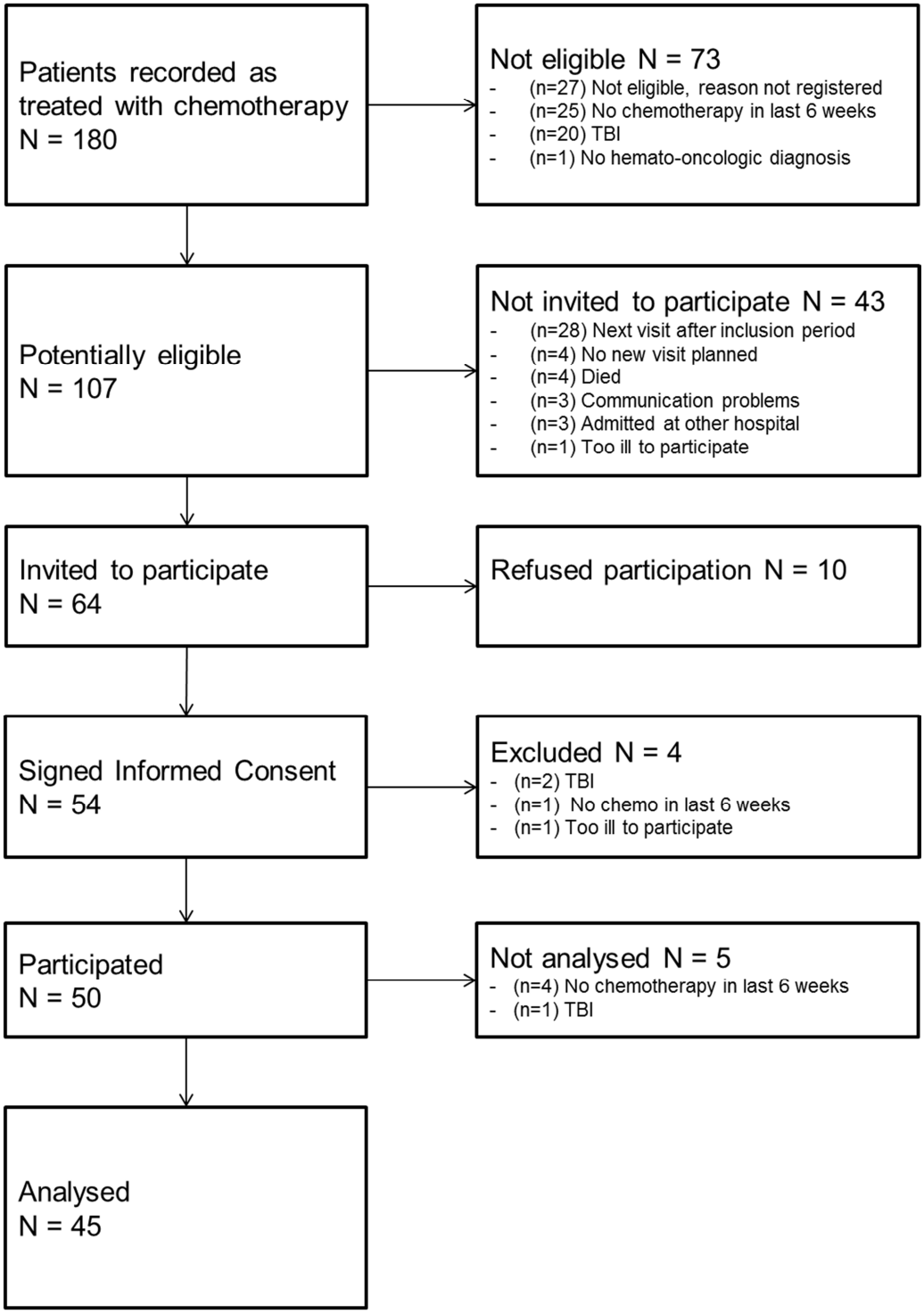

Figure. Flow diagram

FIGURES AND TABLES (2)

Table 1. Socio-demographic and clinical characteristics (n = 45) [a]

Variable	Outcome	
Age	51.16 ± 16.747[b]	53 (19-86)[c]
Sex	28 Male (62.2%)	
Nationality	43 Dutch (95.6%)	2 Other (4.4%)
Smoking	39 No (86.7%)	6 Yes (13.3%)
Home situation	7 Living alone (15.6%)	38 Living with others (84.4%)
Highest education	10 University (22.2%) 24 Vocational training (53.3%) 11 High school (24.4%)	
Type of cancer	10 Multiple Myeloma (22.2%) 9 Acute Lymphoid Leukemia (20%) 7 Hodgkin Lymphoma (15.6%)	7 Non Hodgkin Lymphoma (15.6%) 5 Acute Myeloid Leukemia (11.1%) 7 Other (15.6%)
Body Mass Index	25.84 ± 4.15[b]	25.34 (16.95-42.15)[c]
> 5% weight loss in past 1 month	8 (17.8%)	
> 10% weight loss in past 6 months	5 (11.1%)	
Number of patients who received specific chemotherapy regimen in 6 weeks before participation	19 Cyclofosfamide (42.2%) 13 Vincristine (28.9%) 13 Doxorubicine (28.9%) 11 Cytarabine (24.4%)	11 Etoposide (24.4%) 7 Bleomycine (15.6%) 7 Procarbazine (15.6%) <5 Other [d]

Abbreviations: SD, Standard Deviation.

[a] Values given are n (%)

[b] Values given are mean ± SD

[c] Values given are median (range)

[d] Less than 5 patients received: Methotrexate; Oral Cyclofosfamide; Amsidine; Fludarabine; Vidaza; Melfalan; Busulfan; Daunorubicin; Chloorambucil; Lomustine; Hydrea; Idarubicine; 6-Thioguanine; 6-Mercaptopurine; PEG-asparaginase

FIGURES AND TABLES (3)

Table 2. Total score & Prevalence (Chemosensory Questionnaire)

Total score	Prevalence[a]
4 – 8	4 (8.9%)
9 – 12	16 (35.6%)
13 – 16	19 (42.2%)
17 – 20	6 (13.3%)

[a] Values given are n (%)

Table 3. Severity (Chemosensory Questionnaire)[a]

Question	Answer			
	Never	Rarely	Frequently	Always
1 Food has tasted good	0 (0%)	7 (15.6%)	15 (33.3%)	8 (17.8%)
2 My sense of taste has bothered me	5 (11.1%)	8 (17.8%)	9 (20%)	5 (11.1%)
3 Food has tasted bland	9 (20%)	9 (20%)	12 (26.7%)	3 (6.7%)
4 I have had a bad taste in my mouth	13 (28.9%)	7 (15.6%)	10 (22.2%)	2 (4.4%)

[a] Values given are n (%)
[b] The scores of question 2, 3 and 4 had to be reversed for statistical analysis

FIGURES AND TABLES (4)

Table 4. Univariate association with taste alterations

Variable	Odds Ratio	95% Confidence Interval		P-value
Smell	.715	.554	.921	.010[a]
Type of cancer (yes vs. no):				
- Hodgkin Lymphoma	10.286	1.120	94.443	.039[a]
Type of chemotherapy (yes vs. no):				
- Cytarabine	.198	.037	1.053	.058[b]
- Bleomycine	10.286	1.120	94.443	.039[a]
- Procarbazine	10.286	1.120	94.443	.039[a]
Blood levels:				
- High Fe (>32 vs. <32)	6.875	1.682	28.097	.007[a]
- Low Vitamin D (<25 vs. >25)	6.125	1.092	34.346	.039[a]
- Low Vitamin B12 (<150 vs. > 150)	1.001	1.000	1.002	.099[b]
High Body Mass Index (>25 vs. <25)	4.148	1.179	14.589	.027[a]

[a] Significant at P <.05 level
[b] P <.10; variable could be entered in prediction model

Table 5. Multivariate model for taste alterations

Variables in the equation	Odds Ratio	95% Confidence Interval		P-value
High Fe (>32 vs. <32)	8.582	1.795	41.024	.007[a]
High Body Mass Index (>25 vs. <25)	4.743	1.065	21.124	.041[a]

[a] Significant at P <.05 level

NEDERLANDSE SAMENVATTING (DUTCH SUMMARY)

Titel Smaakbeleving bij Hemato-Oncologische Patiënten: Een Cross-Sectioneel Design

Inleiding Wereldwijd worden steeds meer mensen gediagnosticeerd met kanker en daarvoor behandeld met chemotherapie. Patiënten ervaren hierdoor ernstige bijwerkingen zoals smaakveranderingen, wat kan leiden tot ondervoeding en verminderde kwaliteit van leven. Gezien het gebrek aan kennis over smaakbeleving, met name bij hemato-oncologiepatiënten, was meer onderzoek nodig.

Doel en onderzoeksvraag Het doel van deze studie was, door het verbeteren van kennis over smaakbeleving, het mogelijk maken voor verpleegkundigen en andere gezondheidswerkers om evidence based informatie en ondersteuning te kunnen bieden aan hun patiënten. De onderzoeksvragen waren: wat is de prevalentie en mate van smaakverandering bij hemato-oncologische patienten die chemotherapie krijgen, en zijn Type kanker, Type Chemotherapie, Body Mass Index (BMI), Bloedwaardes (Ijzer (Fe), Vitamine A, Vitamine B12, Vitamine D, Zink, Magnesium), Geur, Orale mucositis, Vermoeidheid, Verminderde eetlust, Leeftijd en Roken geassocieerd met veranderde smaakbeleving?

Methode In een cross-sectioneel design, bestond deelname uit: 1. Vragenlijst, waaronder Chemosensorische vragenlijst en kwaliteit van leven; 2. Bloedafname; 3. Lichaamsmetingen, waaronder BMI en Orale Mucositis score (OMNI). Univariate en multivariate binaire logistische regressie-analyse werden uitgevoerd.

Resultaten Bijna de helft van 45 patiënten heeft last van smaakveranderingen. Univariate analyse resulteerde in significante verbanden ($P<.05$) tussen smaakscore en geur, Hodgkinlymfoom, Bleomycine, Procarbazine, Ijzer (Fe), laag Vitamine D en hoog BMI. Het multivariate model laat een significant verband zien tussen hoog Fe, hoog BMI en smaakverandering (Hoog Fe: OR 8.582, $P=.007$; Hoog BMI: OR 4.743, $P=.041$).

Conclusie Veel patiënten hebben last van smaakveranderingen. Gezien de hoge prevalentie, is meer aandacht nodig voor smaakveranderingen bij hemato-oncologiepatiënten, met name met hoog BMI en hoog Fe.

Aanbevelingen Voor verpleegkundigen en andere gezondheidsmedewerkers is het belangrijk om patiënten te informeren over het mogelijk optreden van smaakveranderingen bij chemotherapie.

Trefwoorden Smaakverandering, Chemotherapie, Hematologie, Ijzer (Fe), Body Mass Index

ABSTRACT

Title Taste Perception in Hemato-Oncology patients: A Cross-Sectional Design

Background Worldwide more and more people are diagnosed with cancer and treated with chemotherapy. Patients experience severe chemotherapy-induced taste alterations, which can lead to malnutrition and lower quality of life. Regarding the lack of knowledge, especially in hemato-oncology patients, more research was needed.

Aim and research question This study aimed to enable nurses and health care workers to give their patients evidence based information, according to taste alterations. The research questions were: what is the prevalence and severity of taste alterations in chemotherapy-receiving hemato-oncology patients, and are Type of Cancer, Type of chemotherapy, Body Mass Index (BMI), Blood levels (Iron (Fe), Vitamin A, Vitamin B12, Vitamin D, Zinc, Magnesium), Smell, Oral Mucositis, Fatigue, Appetite loss, Age and Smoking associated with taste alterations?

Methods In a cross-sectional design, patients completed: 1. Questionnaire, including Chemosensory Questionnaire and quality of life; 2. Blood sample 3. Body measurements: BMI, Oral Mucositis Nursing Instrument. Univariate and multivariate binary logistic regression analysis were used.

Results Almost half of 45 patients had taste alterations. Univariate analysis showed significant associations ($P<.05$) with Hodgkin lymphoma, Bleomycine, Procarbazine, Iron (Fe), low Vitamin D and high BMI. The multivariate model showed a significant association between High Fe, High BMI and taste alterations (High Fe: OR 8.582, $P=.007$; High BMI: OR 4.743, $P=.041$).

Conclusion Many patients suffer from taste alterations. Regarding the high prevalence, more attention for taste alterations in hemato-oncology patients is needed, especially in patients with high BMI and high Fe.

Recommendations For nurses and other health care workers, it is important to inform patients about the possible occurrence of chemotherapy-induced taste alterations. More research is needed.

Keywords Dysgeusia, Chemotherapy, Hematology, Iron (Fe), Body Mass Index

APPENDIX

Appendix. Factors not associated with taste alterations

Variable	Odds Ratio	95% Confidence Interval		P-value
Age	.987	.952	1.023	.469
Smoking	1.294	.232	7.234	.769
Type of cancer:				
- Multiple Myeloma	1.333	.326	5.455	.689
- Acute Lymphoid Leukemia	.286	.052	1.567	.149
- Non Hodgkin Lymphoma	.211	.022	1.972	.172
- Acute Myeloid Leukemia	.815	.123	5.418	.832
Type of chemotherapy:				
- Cyclofosfamide	1.778	.537	5.891	.347
- Vincristine	1.705	.465	6.249	.421
- Doxorubicine	2.667	.707	10.052	.147
- Etoposide	2.827	.690	11.577	.149
Quality of Life:				
- Appetite loss	1.014	.993	1.035	.186
- Fatigue	1.013	.989	1.037	.287
Blood levels:				
- Vitamin A	1.181	.791	1.763	.415
- Magnesium	3.004	.005	1 812.225	.736
- Zinc	.924	.719	1.187	.534
Oral Mucositis	1.194	.868	1.641	.276