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ORIGINAL ARTICLE

# The impact of hematological malignancies and their treatment on oral health-related quality of life as assessed by the OHIP-14: a systematic review

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## Abstract

Patients with hematologic cancers often develop acute and chronic oral complications from their disease and its treatment. These problems could change patients' oral health-related quality of life (OHRQoL) negatively. Quality of life (QoL) has become an increasingly important outcome measure in oncology. This systematic literature review evaluates the impact of hematological malignancies and their treatment on OHRQoL as assessed by the Oral Health Impact Profile (OHIP-14) questionnaire. Medline through Pubmed and Web of Science were searched through April 2017. Two randomized controlled trials, one cohort study, one cross-sectional study, and one case–control study were included. Heterogeneity across the included studies did not allow for meta-analysis. OHIP-14 domains that were frequently given the highest scores were functional limitation (67%), physical pain (50%), physical disability (50%), and psychological discomfort (33%). The domains that were frequently given the lowest scores were social handicap (100%), social disability (100%), and psychological disability (67%). Insufficient evidence is available to draw any robust conclusions regarding OHRQoL assessed by the OHIP-14 in individuals with hematological malignancies. However, functional limitations because of problems with oral mucosal tissues, the dentition, or dentures, seem to have a larger negative impact on the OHRQoL than social aspects associated with oral health problems. Well-designed larger studies are required to determine effects of hematological malignancies as well as acute and long-term effects of their treatment on patients' OHRQoL

**Keywords** Oral health-related quality of life · Oral health · Quality of life · Cancer · Oncology

## Introduction

Patients with hematologic malignancies are commonly confronted with oral complications. These include oral sequelae of the malignancy itself as well as those associated with (radio)chemotherapy and hematopoietic stem cell transplantation (HSCT). Oral manifestations, like gingival enlargement, periodontal disease, osteolytic lesions and bone pain, may be early signs and symptoms of acute leukemia [1, 2]. Treatment-related oral complications may be acute or late and include painful oral mucositis, infections, salivary gland dysfunction, and taste alteration. Oral mucositis remains a frequent acute complication of hemato-oncologic treatments including HSCT, that causes significant suffering for patients [3].

Improvements in treatments and supportive care have resulted in a decreased mortality. As a consequence, nowadays more patients experience living with the aftermath of cancer therapy [4] and may develop long-term oral and

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dental complications [5]. Particularly, oral Graft versus Host Disease (GvHD) that may develop following allogeneic HSCT (with stem cells from a donor) may cause morbidity [6]. Oral GvHD may exist for months to years. In about 80% of patients with chronic GVHD, oral symptoms are present [7].

Quality of life (QoL) has become an increasingly important outcome measure in oncology [8]. Oral health-related quality of life (OHRQoL) represents QoL in relation to perceived oral health and is a part of general health, satisfaction, and wellbeing. The experience of QoL is extremely subjective and could be influenced by a patients' acceptance of having cancer and ability to deal with it, anticipation, and wellbeing over time [9]. Moreover, QoL may be related to disease symptoms and side effects of cancer treatment [8]. The oral health impact profile (OHIP) has been developed to assess QoL in relation to oral health based on the World Health Organization (WHO) guidelines to measure QoL with the aim to distinguish systematically between functional limitation and social burden from physical complaints [10]. Prior to evaluating oral and dental symptoms more precisely, the OHIP-14 can be used as a short initial screening of OHRQoL. The OHIP-14, a shortened version of the OHIP-49, comprises 14 items that measure seven domains of impact, each based on two questions: functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability and social handicap (Table 1). The OHIP-14 consists of a 5-point Likert scale ranging from 0 = never to 4 = very often according to the frequency of the impact [11].

The purpose of this study is to perform a systematic literature review aimed to evaluate the impact of hematological malignancies and their treatment on Oral Health-Related QoL, measured by OHIP-14.

## Material and methods

### Search strategy

A systematic review of the literature was performed using the databases of Medline through PubMed on April 10th 2017, and Web of Science on April 12th 2017.

The database of Medline was searched for articles using keywords that are related to cancer, OHIP-14 questionnaire, and oral health-related quality of life. The search was conducted using the terms [(Oral Health/statistics and numerical data [Mesh]) OR (Oral Health [Mesh]) OR (Quality of life [Mesh]) OR (Oral health related quality of life) OR (OHRQoL) OR (Oral health-related quality of life) OR (Oral-health-related quality of life)] AND [(OHIP 14) OR (OHIP-14) OR (OHIP-14) OR (OHIP-14) OR (OHIP14) OR (OHIP-14sp) OR (OHIP-NL14) OR (short-form Oral Health Impact Profile) OR (Oral Health Impact Profile) OR (Oral Health Impact Profile Questionnaire)] AND [(Cancer) OR (Oncology) OR (Malignancy) OR (Malignant) OR (Tumor) OR (Lymphoma) OR (Leukemia) OR (Stem Cell Transplantation)].

For the search of Web of Science the following terms were used; [(oral health) OR (quality of life) OR (oral health related quality of life) OR (OHRQoL) OR (Oral Health-related quality of life) OR (oral health-related quality of life) OR (oral-health-related quality of life)] AND [(OHIP 14) OR (OHIP-14) OR (OHIP- 14) OR (OHIP -14) OR (OHIP14) OR (OHIP-14sp) OR (OHIP-NL14) OR (short-form Oral Health impact profile) OR (oral health impact profile) OR (oral health impact profile questionnaire)] AND [(cancer) OR (malignancy) OR (malignant) OR (tumor) OR (lymphoma) OR (leukemia) OR (stem cell transplantation)].

**Table 1** 14 items of the oral health impact profile, OHIP-14

| Domain | Question |
|---|---|
| Functional limitation | 1. Have you had trouble pronouncing any words because of problems with your teeth, mouth or dentures? |
| | 2. Have you felt that your sense of taste has worsened because of problems with your teeth, mouth or dentures? |
| Physical pain | 3. Have you had painful aching in your mouth? |
| | 4. Have you found it uncomfortable to eat any foods because of problems with your teeth, mouth or dentures? |
| Psychological discomfort | 5. Have you been self conscious because of your teeth, mouth or dentures? |
| | 6. Have you felt tense because of problems with your teeth, mouth or dentures? |
| Physical disability | 7. Has your diet been unsatisfactory because of problems with your teeth, mouth or dentures? |
| | 8. Have you had to interrupt meals because of problems with your teeth, mouth or dentures? |
| Psychological disability | 9. Have you found it difficult to relax because of problems with your teeth, mouth or dentures? |
| | 10. Have you been a bit embarrassed because of problems with your teeth, mouth or dentures? |
| Social disability | 11. Have you been a bit irritable with other people because of problems with your teeth, mouth or dentures? |
| | 12. Have you had difficulty doing your usual jobs because of problems with your teeth, mouth or dentures? |
| Social handicap | 13. Have you felt that life in general was less satisfying because of problems with your teeth, mouth or dentures? |
| | 14. Have you been totally unable to function because of problems with your teeth, mouth or dentures? |

### Eligibility criteria

First, the title and abstract from the identified records of the search strategy were screened by two independent reviewers (JS and KCEV). Second, English full-text articles were screened and selected (JS and KCEV), using the following eligibility criteria:

- Randomized controlled trials (RCT) or observational study designs: cohort-, cross sectional-, case–control studies
- Human patients of all ages with a hematological cancer
- Oral health-related quality of life quantified by OHIP-14

Articles without abstract, but with titles suggesting potential eligibility were read in full text. Articles that did not meet all eligibility criteria were excluded. Disagreements between the reviewers were resolved by discussion until consensus was reached.

### Assessment of heterogeneity

Heterogeneity across included studies (both observational and RCTs) was evaluated using the following criteria:

- Study design
- Purpose
- Country
- Cancer characteristics (gender, age, cancer type, cancer therapy)
- (Type of) control group
- Time point(s) at which the questionnaire(s) were completed
- Follow-up (time after diagnosis or therapy) of patients
- OHIP-14 results: scale, number completed questionnaires
- OHIP-14 results: related to cancer type and therapy
- OHIP-14 results: overall OHIP scores, scores per domain or per question
- OHIP-14 results: total scores (sum of individual scores) or individual scores
- OHIP-14 results: mean value, standard deviation, standard error or none
- OHIP-14 results: range of values

### Quality assessment

Quality assessment of the included studies was performed according to the Cochrane's Collaboration's tool, described in Handbook version 5.1.0.[12]. Additional factors have been added as 'Other/confounding bias'. Of less importance for the quality assessment in this systematic review are selection bias and performance bias; as only studies involving patients with hematological cancers were included, these types of bias were considered having no significant influence on OHIP-14 results. The quality of each article for the risk of bias was assessed independently by the same authors who did the search and screened the articles.

Studies were assessed as high risk of bias when one or more domains were classified as high risk. When a study satisfied all domains, it was rated as low risk of bias. Studies were judged as unclear risk of bias when the risk of bias was unclear in one or more domains.

## Results

### Search results

The initial search of Medline resulted in 56 articles and The Web of Science search resulted in 86 articles (Fig. 1). After removing duplicates, a total of 113 articles were initially retrieved. Papers were excluded based on the following criteria: not English, not related to hematological cancer patients and OHIP-14. Following these criteria, 34 full-text articles were considered for inclusion. After reading these full text articles, another 29 studies were excluded. Reasons for exclusion were use of another OHIP questionnaire (OHIP-G, OHIP-EDENT, OHIP-49), subjects with another diagnosis than hematological cancer, no (detailed) results provided, and duplication of articles reporting exactly the same study results. Finally, 5 studies met the inclusion criteria for systematic review.

### Assessment of heterogeneity

#### Characteristics of the trial design

Table 2 shows a summary of important characteristics of the included studies. Two of these studies were RCTs [13, 14], one cohort study [15], one cross-sectional study [16], and one case–control study [17]. Four trials were conducted in Brazil [14–17] and one in Italy [13]. The total number of patients with hematological malignancies varied from 309 to 352 (due to missing data). Three studies compared OHIP-14 results of an experimental group with a control group. Control subjects were obtained by randomization [13, 14] or consisted of healthy non-cancer patients, matched on age and gender [17].

#### Characteristics of patients

Hematological malignancies included lymphoma and leukemia [16], acute lymphoblastic leukemia [13], lymphoma, myeloma, leukemia and myelodysplastic syndromes [15], lymphoma, myeloma, leukemia, myelodysplastic syndromes and hemoglobinuria [14], lymphoma, myeloma, leukemia,

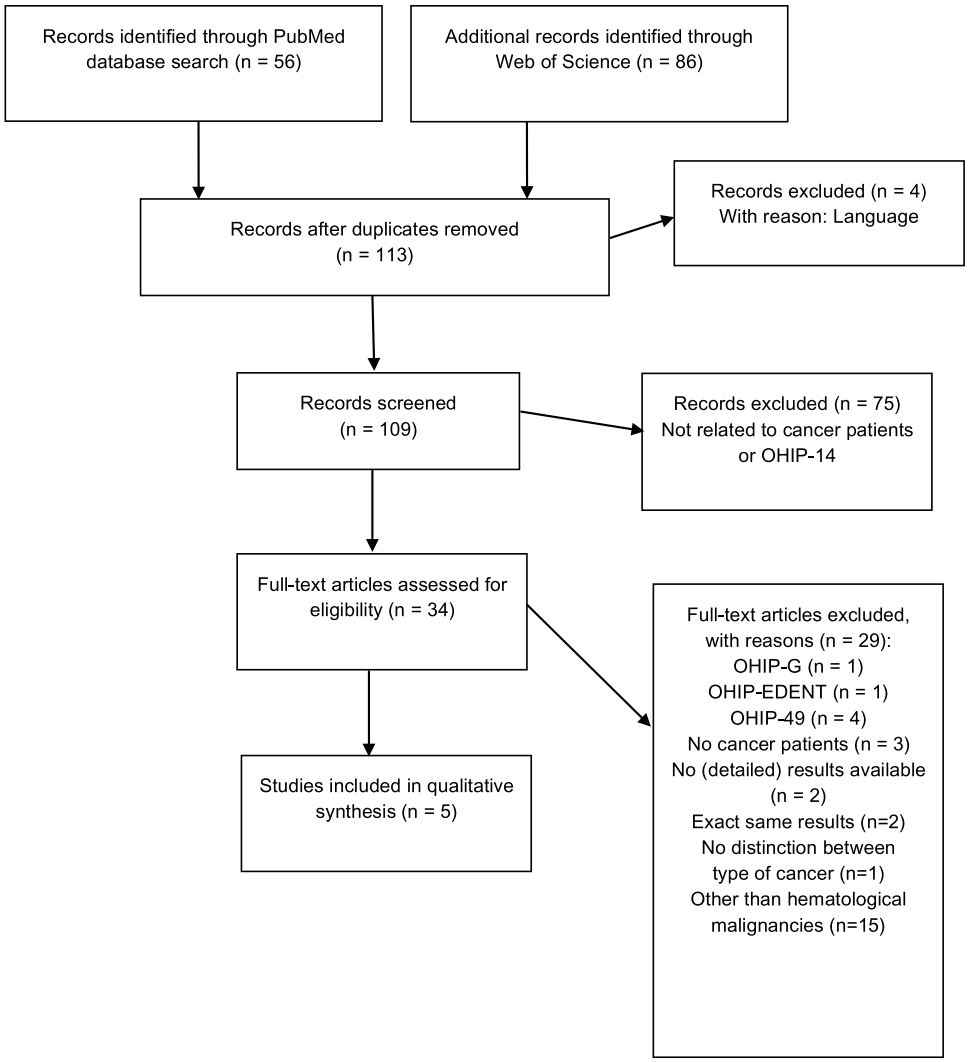


**Fig. 1** Prisma flow diagram of the systematic review process. This figure shows our search results in detail. Five studies met the inclusion criteria: human hematological cancer patients and Oral Health-Related Quality of Life quantified by OHIP-14

myelodysplastic syndromes [17]. None of the studies reported the tumor stage.

Three types of cancer therapies and/or supportive care interventions of patients suffering from hematological malignancies could be distinguished: chemotherapy only [13, 16], (autologous or allogeneic) HSCT conditioning regimens (chemotherapy with or without total body irradiation), combined with [15] (laser group) and without low-level laser therapy (control group) [14]. One study [17] included patients who were planned to be treated with conditioning therapy for HSCT but did not receive the conditioning regimen yet.

Four studies included children and adult patients [14–17]. In one study, all patients were 6–14 years of age [13].

### Time-points

Two studies evaluated the OHIP-14 only once. In one of these studies, participants filled out the questionnaire before cancer treatment [17], and in one study during treatment [16]. One study evaluated the OHIP-14 at two time points. The study of Bardellini et al. [13] completed OHIP-14 twice during cancer treatment (one time before and one time after using a specific toothpaste for the management of oral mucositis). One study evaluated the OHIP-14 at three time points; patients in the study of Silva et al. [14] completed OHIP-14 at admission, as well as 7 and 20 days after HSCT. In the study of Bezinelli et al. [15] the OHIP-14 was completed at four time points: before beginning of the conditioning treatment for HSCT, on the fifth day after autologous HSCT or on the eighth day after allogeneic transplant, at bone marrow engraftment, and 30 days after patient discharge.

### Follow-up time

None of the studies reported the time between therapy and completing the OHIP-14. In four studies, the follow-up time

**Table 2** Characteristics of the included studies

| Study | Design | Purpose | Experimental group ($n$ = number of patients) | Control group ($n$ = number of patients) | OHIP-14 results: scale | Number completed questionnaires | Time point(s) at which the questionnaire(s) were completed | OHIP-14 scores[a] |
|---|---|---|---|---|---|---|---|---|
| Bardellini et al. [13] | RCT | The influence of toothpaste on oral hygiene grade and on QoL of children with oral mucositis grade 1 or 2 receiving chemotherapy for ALL | Bioxtra toothpaste ($n$ = 32) | Fluoride toothpaste without menthol ($n$ = 32) | 0 = never, 1 = hardly ever, 2 = occasionally, 3 = fairly often, 4 = very often | 64 | T0: on the first day of diagnosis of oral mucositis<br>T1: after 8 days | Overall OHIP scores per individual with range of values |
| Silva et al. [14] | RCT | The influence of laser therapy on oral mucositis and QoL of patients treated with HSCT | Low-level laser therapy ($n$ = 20) | No laser therapy ($n$ = 19) | 0 = never, 1 = hardly ever, 2 = occasionally, 3 = fairly often, 4 = very often | 0 days after HSCT: $n$ = 39, 7 days after HSCT: $n$ = 38, 20 days after HSCT: $n$ = 32 | Time point 1: at admission: 0 days after HSCT<br>Time point 2: 7 days after HSCT<br>Time point 3: discharge: 20 days after HSCT | 1. Overall OHIP scores as a total score (sum of individual scores) with range of values<br>2. Overall OHIP scores as a total score (sum of individual scores) with mean values |
| Bezinelli et al. [15] | Cohort | The impact of oral mucositis on QoL of patients subjected to HSCT treated with low-level laser therapy | Low-level laser therapy (100%)<br>HSCT $n$ = 69 (100%)<br>Chemotherapy $n$ = 69 (100%)<br>Total Body Irradiation $n$ = 11 (15.94%) | - | Likert scale (0–4, where 0 = never and 4 = always) | 69 | Time point 1: Before beginning HSCT; Time point 2: On the 5th day after autologous transplant or on the 8th day after allogeneic transplant; Time point 3: When the bone marrow had integrated (absolute neutrophil count > 500); Time point 4: 30 days after patient discharge | 1. Scores per domain per individual with unclear mean value<br>2. Overall OHIP scores per individual with unclear mean value |

**Table 2** (continued)

| Study | Design | Purpose | Experimental group ($n$ = number of patients) | Control group ($n$ = number of patients) | OHIP-14 results: scale | Number completed questionnaires | Time point(s) at which the questionnaire(s) were completed | OHIP-14 scores[a] |
|---|---|---|---|---|---|---|---|---|
| Grando et al. [16] | Cross-sectional | Influence of leukemia and lymphoma and chemotherapy on OHRQoL | Non-Hodgkin's lymphoma: $n$ = 38 (47.5%); Acute leukemia: $n$ = 27 (33.75%); Hodgkin's lymphoma: $n$ = 11 (13.75%); Chronic leukemia: $n$ = 4 (5%); Intravenous chemotherapy medication (100%) | – | 0 = never, 1 = rarely, 2 = sometimes, 3 = repeatedly, 4 = always | 44 | 1 time point: during intravenous chemotherapy medication | Scores per question per individual as mean value and standard deviation/standard error |
| Tinoco-Araujo et al. [17] | Case–control | OHRQoL of patients contemplating HSCT | Patients with cancer prior to allogeneic or autologous HSCT ($n$ = 100) | Healthy volunteers ($n$ = 100) | Unclear information | 100 | One time: prior to HSCT (contemplating) | 1. Scores per domain per individual as mean values<br>2. Overall OHIP scores per individual as mean values |

[a]Overall scores, scores per domain or per question; total (sum of individual scores) or individual scores; mean value, sd/se/none, range of values

was unclear [13–16]. In one study, the OHIP-14 questionnaire was evaluated only prior to the cancer treatment, and no follow-up evaluation was performed [17].

### Scale

The studies used several ways to score the OHIP-14 items. The original Likert scale uses five points ranging from 0 to 4 (0 = never, 1 = hardly ever, 2 = occasionally, 3 = fairly often, and 4 = very often). Two studies [13, 14] used this original five-point Likert scale. Bezinelli et al. [15] modified the phrasing of score 4 into "always". One study used other words corresponding to the numbers of the scale: 0 = never, 1 = rarely, 2 = sometimes, 3 = repeatedly, and 4 = always [16]. One study [17] did not provide clear information about the scale.

### Way of reporting OHIP-14 results

Four studies reported overall OHIP-14 scores [13–15, 17]. The study of Bardellini et al. [13] presented the OHIP-14 scores as median values. The study of Silva et al. [14] presented the results in a figure and a table. The overall OHIP-14 scores of both groups together were presented as median values. Two studies reported scores per domain [15, 17]. The study of Bezinelli et al. [15] presented the results in a figure. One case–control study reported mean values [17]. One study [16] reported the OHIP-14 scores (mean values) per question and reported only the results of the participants who scored 3 = repeatedly and 4 = always.

## Quality assessment

Table 3 shows the risk of bias in all included studies. All studies [13–17] had at least one domain with a high risk of bias. As a consequence, all studies were assessed as high risk of bias. The lowest risk of bias was observed for Bardellini et al. [13]. The highest risk of bias was observed for the study of Bezinelli et al. [15].

One study was assessed as having high risk of attrition bias [16], because of the high drop-out rate of participants (55%). One study was assessed as high risk of reporting bias, because there was no explanation for reporting only OHIP-14 results of 44 out of 80 included participants [16]. Three of the five studies [14, 15, 17] did not relate the OHIP-14 results to a homogenous group of hematological cancer patients. In two studies [14, 15], the OHIP-14 results were not related to a homogenous type of therapy. Three studies [13–15] evaluated OHIP-14 at several time points and blinding of participants for the OHIP-14 assessment in time was not performed. The results in the study of Grando et al. [16] were corrected for gender, type of cancer and examination site but only for the patients who scored 3 and 4 on the OHIP-14 scale.

In the study of Bardellini et al. [13], the patients had oral mucositis and they frequently used strong analgesics

**Table 3** The risk of bias in all included studies (top-down) according to Cochrane Collaboration's biases tool [12] (from left to right). The green dot indicates low risk of bias, whereas the red dot indicates high risk of bias. The orange dot indicates an unknown risk of bias

| Article | Blinding of outcome assessment (detection bias) | Blinding of data-analysis (detection bias) | Incomplete outcome data (attrition bias) | Selective reporting (reporting bias) | Heterogeneity, type of cancer (other bias) | Heterogeneity, type of (cancer)therapy (other bias) | Blinding in time (other bias) | Measuring confounding factors (other bias) | Other, confounding bias |
|---|---|---|---|---|---|---|---|---|---|
| Bardellini et al, 2016 [13] | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Silva et al, 2015 [14] | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Bezinelli et al, 2016 [15] | | ● | ● | ● | ● | ● | ● | ● | ● |
| Grando et al, 2015 [16] | ● | ● | ● | ● | ● | ● | | ● | ● |
| Tinoco-Araujo et al, 2015 [17] | ● | ● | ● | ● | ● | | | ● | ● |

to control the concomitant pain. This could be a confounding factor because these pain medications can affect patients' perception of QoL. In the study of Silva et al. [14], three patients in the control group, who did not receive low-level laser therapy, developed grade 3 oral mucositis. Therefore, low-level laser treatment was administered for ethical purposes. The study reported that this did not change the results. However, no data were presented. In one study [17], children were evaluated with parenteral collaboration. In Bezinelli et al. [15], three parents completed the questionnaire on behalf of their children because their children were unable to read.

### Overall analysis of OHIP-14 outcomes

Heterogeneity across included studies did not allow for meta-analysis. To summarize the OHIP-14 scores of different domains, we identified the two highest and the two lowest scored domains of all OHIP-14 time-measurements of the studies that included patients with hematological malignancies (Fig. 2). When two or more domains had similar highest/lowest scores, they were all included in this analysis.

There were six evaluations. Two studies only reported overall OHIP-14 scores [13, 14]. The remaining three studies reported scores per domain [15, 17] or per question [16].

The domains that were frequently given the highest scores were functional limitation (67%), physical pain (50%), physical disability (50%) and psychological discomfort (33%). The domains that were frequently given the lowest scores were social handicap (100%) and social disability (100%) and psychological disability (67%).

## Discussion

The aim of this systematic review was to evaluate the OHRQoL of individuals with hematological malignancies using the OHIP-14. In addition to oral problems caused by these malignancies, acute side effects and long-term complications of (radio)chemotherapy and complications related to HSCT (e.g., oral GvHD) can influence patients' OHRQoL [18].

OHRQoL was negatively influenced by the domains functional limitation (trouble pronouncing words, worsened sense of taste), physical pain (painful aching, uncomfortable to eat), physical disability (unsatisfactory diet, interrupt meals) and psychological discomfort (felt less self-conscious, felt tense). The domain functional limitation had the largest influence on the patients' OHRQoL (Fig. 2).

High-dose chemotherapy followed by HSCT is frequently associated (70–80%) with severe oral mucositis (grade 3–4) [19], and mucositis severity may be even higher in patients who received TBI [18]. Other oral complications frequently seen at diagnosis and during treatment of leukemia and lymphoma are dental pain [20] and pain associated with bacterial, viral and fungal infections [21, 22]. In allogeneic HSCT recipients developing chronic oral GvHD, painful oral ulceration, infection, hyposalivation and xerostomia, and taste alterations are among the most commonly reported problems [7, 23, 24]. All of these complications may be possible explanations for the relatively large negative impact of physical complaints that affect the OHIP-14 score, and thus OHRQoL.

Poor nutrition or difficulty with oral intake, difficulty in mastication and in some cases the need for parenteral nutrition, likely impacts OHRQoL also negatively. Oral pain, altered taste and/or smell, nausea, and problems with

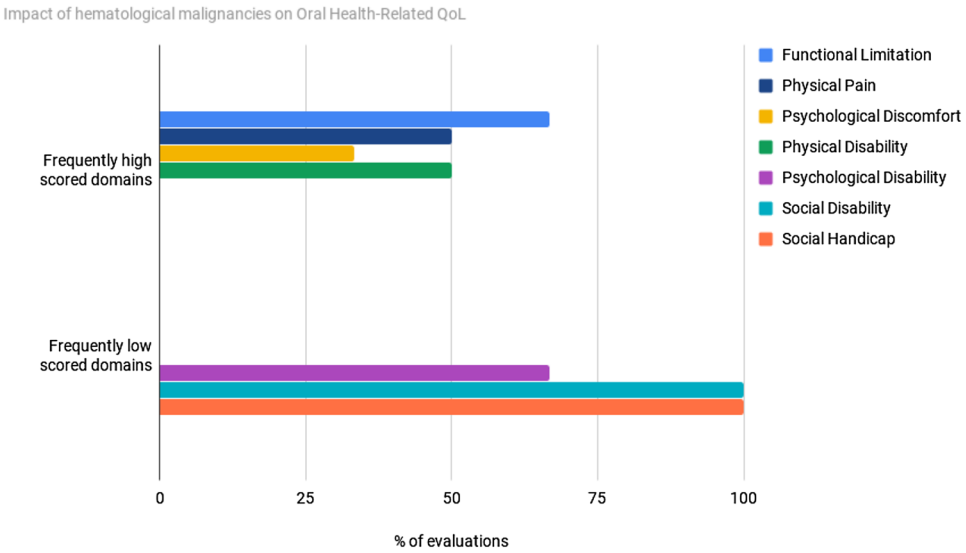


**Fig. 2** Frequently high and low scored domains of OHIP-14 by patients with hematological malignancies. This figure shows the % of evaluations in which domains of OHIP-14 were frequently given the highest and lowest scores

swallowing (dysphagia or odynophagia) may lead to a compromised nutritional state and can affect the pleasure of eating [25, 26]. QoL can be significantly limited when a combination of oral mucositis, swallowing problems, altered taste and dry mouth occurs [27].

Difficulty in eating and drinking and/or changes in the taste of food may result in malnutrition, decreased resistance to infection, and social complaints like isolation and depressive symptoms which may negatively affect QoL [28, 29]. Patients, who have undergone HSCT, have more severe xerostomia than the comparison group not treated with HSCT. Besides affecting taste and increasing infection risk, a dry mouth can also affect speaking and swallowing [5]. In turn, problems with speech and lack of communication may lead to depression and isolation [25]. Isolation of patients may explain the low influence of the domains social disability and social handicap on OHRQoL (Fig. 2). Being isolated may cause fewer social problems than being among people in social situations.

It should be emphasized that this systematic review has several limitations. No meta-analysis could be performed. This was due to the heterogeneity between the included studies. Some studies [15–17] changed the original Likert-scale or did not provide clear information about the scale. As a consequence, the validity of the OHIP-14 results decreases [30]. Furthermore, there was heterogeneity in reporting the OHIP-14 questionnaire results, missing mean numbers or standard deviations, and a limited number of study participants in each study. As a consequence, insufficient information is available about the OHRQoL, oral symptom burden of hematological cancers itself and their treatment as assessed by the OHIP-14. Because of heterogeneity in results, it could be argued whether the OHIP-14 alone is the optimal tool to assess OHRQoL of patients with hematological cancers. The EORTC QLQ-OH17 and more recently the EORTC QLQ-OH15 have been designed specifically for assessing OHRQoL in cancer patients [31, 32]. However, a potential advantage of the OHIP-14 is that it is not merely based on the OHRQoL of the past week like the EORTC questionnaires [31, 32], but on the past month [30]. To determine a multidimensional concept of QoL, the OHIP-14 can be combined with the EORTC QLQ-OH15 and EORTC QLQ-C30 and inform the clinician about specific oral complications and supportive care needs [32]. This information is extremely important to improve clinical practical guidelines to provide optimal supportive care aimed to prevent severe problems that may have a negative impact on OHRQoL and global QoL. Further research is required to investigate these patient-reported outcomes.

To perform a meta-analysis, future studies must include the points mentioned below in their study design. Future studies should have the same purpose: to assess the impact of hematological malignancies on OHRQoL, as assessed by the OHIP-14. Patients should be homogeneous in type of cancer and their received therapy, received supportive oral care regimen, and the characteristics of patients should be mentioned more precisely. When the study includes patients with different types of cancer or therapy or tumor stage, OHIP-14 results should specifically relate to these groups. In reporting the OHIP-14 results, all results should be reported: (1) Scores per question, per domain and overall scores. (2) Scores per individual, but when all individuals are homogeneous in type of cancer or therapy then a sum of individual scores is allowed. (3) The mean value, the standard deviation and standard error, and the range of values should be reported. The 5-point Likert scale, the standard scale to score OHIP-14 results, should be used by all studies. The scale should not be modified. Further on, when a study chooses to assess the OHRQoL on different time-points after diagnosis or treatment, it should be clearly stated on what time-points this is measured, i.e., the follow up time (time between diagnosis or therapy and completing the OHIP-14 questionnaire).

## Conclusion

All included studies in this systematic review were assessed as having a high risk of bias affecting the evidence of the studies. Due to a wide heterogeneity between the studies, statistical analysis was not possible, and insufficient evidence was available to draw any robust conclusions regarding OHRQoL assessed by the OHIP-14 of individuals with hematological malignancies. However, one pattern could be identified with respect to the impact of cancer or its treatment on patients' OHRQoL. Functional complications because of problems with oral mucosal tissues, the dentition, or dentures, impact the OHRQoL more negatively than social aspects associated with oral health problems. Well-designed larger studies are required to determine effects of hematological malignancies as well as acute and long-term effects of their treatment on patients' OHRQoL. Oral health of hematological cancer patients should be monitored before, during and after treatment by health care practitioners using clinical evaluation and patient-reported outcomes to be able to provide optimal supportive care based in the patient's individual needs. Oral symptoms of patients should be prevented and when present relieved as much as possible to avoid secondary complications, preserve QoL, and optimize the outcome of cancer treatment.

## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

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