## VALIDITY AND RELIABILITY OF THE MALAY QUESTIONNAIRE FOR OLFACTORY DISORDERS

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#### ABSTRAK

Latar belakang: Gangguan bauan adalah istilah am untuk berbagai masalah deria bau. Pelbagai ujian dan soal selidik telah dibuat untuk mengenal pasti dan menentukan tahap gangguan bauan. Namun, kebanyakan soal selidik ini tidak tersedia atau diterjemahkan untuk penduduk Malaysia. Kajian ini bertujuan untuk menterjemahkan Soal Selidik Gangguan Bauan (QOD) kepada bahasa Melayu, mengesahkan dan menguji kebolehpercayaan borang soal selidik gangguan bauan versi Bahasa Melayu (mQOD).

**Metodologi:** Ini adalah kajian keratan rentas yang dijalankan di dua pusat perubatan tertiary. Terjemahan depan dan belakang telah dibuat untuk QOD. Soal selidik yang diterjemahkan telah diedarkan kepada subjek yang mengalami gangguan bauan pada hari pertama dan hari ketujuh. Konsistensi internal diuji menggunakan Cronbach's alpha dan kebolehpercayaan diuji dengan koefisien korelasi intrakelas. Kesahan konstruk diuji melalui analisis faktor konfirmatori.

**Keputusan:** Seramai 375 peserta telah diambil, 52 peserta tercicir manakala 323 melengkapkan soal selidik untuk kali kedua. Cronbach's alpha ialah 0.537 untuk P, 0.892 untuk LQ, 0.637 untuk S dan 0.865 untuk VAS. Koefisien korelasi intrakelas untuk semua markah adalah >0.9, manakala untuk semua soalan adalah bagus dan cemerlang.. Model dengan tiga faktor untuk mQOD menunjukkan ukuran kebagusan penyuaian model yang bagus, iaitu CMIN/DF=3.332, TLI=0.923, CFI=0.939, RMSEA=0.079 and SRMR=0.0574.

**Kesimpulan:** mQOD adalah alat yang sah dan boleh dipercayai untuk menilai gangguan bauan pada pesakit.

Kata kunci: bau, gangguan olfaktori, parosmia, deria bau, soal selidik

#### ABSTRACT

**Background:** Olfactory disorder is an umbrella term for a diverse group of smell problems. Numerous tests and questionnaires have been formulated to identify and test the severity of smell impairment, which is not readily available or not translated for the Malaysian population. We aimed to translate the Questionnaire for Olfactory Disorders (QOD), validate and test the reliability of the Malay questionnaire for olfactory disorders (mQOD).

**Methods**: This was a cross sectional study conducted in two tertiary centres. A forward and back translation was done for the QOD. The translated questionnaire was distributed to subjects with self-reported smell disorders on day one and day seven. Internal consistency was analysed with Cronbach's alpha and test retest reliability tested with intraclass correlation coefficient. Confirmatory factor analysis was done to test construct validity.

**Result:** A total of 375 participants were recruited, 52 participants dropped out and 323 completed the questionnaire a second time. Cronbach's alpha coefficient was 0.537 for P, 0.892 for LQ, 0.637 for S and 0.865 for VAS. The intraclass correlation coefficient (ICC) for domain scores were >0.9, while the ICC for all items were good to excellent. A three-factor model for mQOD showed acceptable fit with indices CMIN/DF=3.332, TLI=0.923, CFI=0.939, RMSEA=0.079 and SRMR=0.0574.

**Conclusion:** The mQOD is a valid and reliable tool for assessing olfactory disorder in patients.

Keywords: smell, olfactory disorder, parosmia, olfaction, questionnaire

## **CHAPTER 1:**

# **INTRODUCTION**

#### 1.0 INTRODUCTION

Olfactory disorders (OD) are becoming increasingly recognized medical problems in our community. Past epidemiological studies have reported that the prevalence of smell disorders range from 2.7% and 24.5%  $c(1)^{(4)}$ . Causes of olfactory impairments can be broadly divided into conductive and sensorineural in nature and at times it may be a combination of both (2)<sup>(2)</sup>. Conductive causes include chronic sinusitis and nasal polyps whereas sensorineural causes are head injury, post viral upper respiratory tract infection, toxin exposure and age-related decline in smell  $\frac{1}{(1)}$ <sup>(4)</sup>. In recent times, the Coronavirus Disease 2019 (COVID-19) has also been identified to cause smell impairments.  $(3-6)^{(3-6)}$ , triggering renewed interest in OD. The nose in particular, plays a major role (7)<sup>-(7)</sup> in causing conductive smell impairment as it acts as a conduit for odourants and contain neuroepithelium necessary for signal transduction<sup>-</sup>(8)<sup>(6)</sup>. As such, it is essential for otorhinolaryngologists to anticipate and evaluate this condition in their patients.

The sense of smell is an invaluable sense that enables us to appreciate the scent of objects and at the same time is capable of acting as a warning signal when encountering potentially hazardous food or environment (9)<sup>( $\theta$ )</sup>. As a result, smell impairment may reduce quality of life and affect activities of daily living (10). <sup>((10)</sup>, <sup>(10)</sup>, <sup>(<math>10)</sup></sup>. The effects of olfactory disorders on a person's life are far reaching, from not being able to smell and enjoy food (10), <sup>(10</sup>, <sup>(10</sup>), <sup>(10</sup>), <sup>(10</sup>, <sup>(10</sup>), <sup>(10</sup>, <sup>(10</sup>), <sup>(10</sup>, <sup>(10</sup>), <sup>(10</sup>), <sup>(10</sup>), <sup>(10</sup>, <sup>(10</sup>), <sup>(</sup></sup>

The Questionnaire for Olfactory Disorders (QOD) is a patient-reported questionnaire that aids clinicians to assess the impact of olfactory impairment on quality of life (14). It consists of two parts: statements and visual analogue scales (VAS). The statements explore three aspects, namely, patient's life quality (QOD-LQ), sincerity (QOD-S), and parosmia (QOD-P). The VAS make up the second part of QOD and give an insight into patient awareness of their olfactory disorder and the degree to which it adversely affects them (14). As it is a valid and reliable tool, it has been employed in numerous studies(15-19).

Since the beginning of the COVID-19 pandemic, more people are suffering from OD, with prevalence reported to be as high as 48%\_(20). Although loss of smell is not immediately life threatening, it impairs their quality of life in multiple aspects, from eating and cooking habits to affecting interpersonal relationships\_(21). With advancement of medical knowledge and technology, we not only try to treat the patient's condition but also ensure that the patient's quality of life is preserved or improved. By translating the QOD into the Malay language, we hope to provide a validated tool that can be applied to Malaysians. The mQOD could be used as a tool to assess the severity of olfactory dysfunction and monitor symptom improvement. As a result, the patient-doctor relationship would be enhanced and pati

This study aims to translate QOD into the Malay language, a common language among the multiracial population of Malaysia, and to validate the Malay version (mQOD).

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## **CHAPTER 2:**

# **OBJECTIVES OF THE STUDY**

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#### 2.0 OBJECTIVES OF THE STUDY 2.1 GENERAL OBJECTIVE

To study the validity and reliability of mQOD in patients with altered smell.

#### 2.2 SPECIFIC OBJECTIVE

1. To examine the reliability of mQOD by determining internal consistency and testretest reliability.

2. To determine the construct validity of mQOD using confirmatory factor analysis.

## **CHAPTER 3:**

## MANUSCRIPT

#### 3.1 TITLE PAGE

#### Validity and Reliability of the Malay Questionnaire for Olfactory Disorders

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

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#### **3.2 ABSTRACT**

**Background:** Olfactory disorder is an umbrella term for a diverse group of smell problems. Numerous tests and questionnaires have been formulated to identify and test the severity of smell impairment, which is not readily available or not translated for the Malaysian population. We aimed to translate the Questionnaire for Olfactory Disorders (QOD), validate and test the reliability of the Malay questionnaire for olfactory disorders (mQOD).

**Methods**: This was a cross sectional study conducted in two tertiary centres. A forward and back translation was done for the QOD. The translated questionnaire was distributed to subjects with self-reported smell disorders on day one and day seven. Internal consistency was analysed with Cronbach's alpha and test retest reliability tested with intraclass correlation coefficient. Confirmatory factor analysis was done to test construct validity.

**Result:** A total of 375 participants were recruited, 52 participants dropped out and 323 completed the questionnaire a second time. Cronbach's alpha coefficient was 0.537 for P, 0.892 for LQ, 0.637 for S and 0.865 for VAS. The intraclass correlation coefficient (ICC) for domain scores were >0.9, while the ICC for all items were good to excellent. A three-factor model for mQOD showed acceptable fit with indices CMIN/DF=3.332, TLI=0.923, CFI=0.939, RMSEA=0.079 and SRMR=0.0574.

**Conclusion:** The mQOD is a valid and reliable tool for assessing olfactory disorder in patients.

Keywords: smell, olfactory disorder, parosmia, olfaction, questionnaire

#### **3.3 INTRODUCTION**

Olfactory disorders (OD) are becoming increasingly recognized medical problems in our community. Past epidemiological studies have reported that the prevalence of smell disorders range from 2.7% and 24.5%<sup>1</sup>. Causes of olfactory impairments can be broadly divided into conductive and sensorineural in nature and at times it may be a combination of both <sup>2</sup>. Conductive causes include chronic sinusitis and nasal polyps whereas sensorineural causes are head injury, post viral upper respiratory tract infection, toxin exposure and age-related decline in smell<sup>1</sup>. In recent times, the Coronavirus Disease 2019 (COVID-19) has also been identified to cause smell impairments <sup>3-6</sup>, triggering renewed interest in olfactory disorders. The nose plays a major role <sup>7</sup> in causing conductive smell impairment as it acts as a conduit for odourants and contain neuroepithelium necessary for signal transduction <sup>8</sup>. As such, it is essential for otorhinolaryngologists to anticipate and evaluate this condition in their patients.

The sense of smell is an invaluable sense that enables us to appreciate the scent of objects and at the same time can act as a warning signal when encountering potentially hazardous food or environment <sup>9</sup>. As a result, smell impairment may reduce quality of life and affect activities of daily living <sup>10</sup>. The effects of olfactory disorders on a person's life are far reaching, from not being able to smell and enjoy food <sup>10</sup>, reduced self-esteem <sup>11</sup>, social isolation <sup>12</sup> and consequently depression <sup>13</sup>. Patients report less enjoyment in food-related activities such as eating, cooking and going out to eat <sup>14</sup> due to not only loss of smell, but also loss of flavour perception. Interestingly this led to either increased food intake to compensate for reduced chemosensory perception or reduced food intake as the food becomes less appealing <sup>15</sup>. Due to the loss in flavour perception, subjects have been reported to compare their eating experience to eating sawdust and cardboard <sup>12</sup>. Patients'

food preferences tend to shift to spicy food to make up for lack in taste and smell <sup>16</sup>, accompanied by a change in cooking habits where they season food more.

Other causes of concern include personal hygiene and social relations<sup>17</sup> as patients worry about body odour or bad breath which they cannot perceive but may be detected by others. For some patients, a defective chemosensory system can even affect their work <sup>17</sup>, especially people in the food industry, perfumers, or firemen. In addition to this, there is also a close association between olfactory impairment and depression <sup>18</sup>. Subjects have smell loss-induced anhedonia and are unable to feel enjoyment <sup>12</sup>. A study in Korea showed that subjects with OD were at higher risk of depression and suicidal thoughts <sup>19</sup>.

Assessment for olfactory function can generally be categorised into three types, namely, psychophysical assessment, imaging studies, and subjective assessment <sup>20</sup>. Psychophysical tests primarily evaluate odour identification, odour thresholds, and odour discrimination. Examples include the University of Pennsylvania Smell Identification Test (UPSIT), Cross-Cultural Smell Identification Test (CCSIT), and Sniffin' Sticks. The UPSIT is the most widely known test and has been shown to have high reliability <sup>21</sup>. It consists of 4 booklets with microencapsulated odourants which patients can self-administer. A variant of the UPSIT, CCSIT tests subjects on 12 odours, 6 food-related and 6 non-food related smells. Even though it is a quicker test to administer, it has been shown to be less reliable than the UPSIT. Sniffin' Sticks uses pen-like odour dispensing devices which assesses all three tests of olfactory function. The downfall of these psychophysical tests is that they cannot be applied universally as some smells are not known in different parts of the world.

There is a scarcity of questionnaires used to evaluate olfactory disorders. The Sino-Nasal Outcome Test (SNOT-22) is a validated questionnaire that explores the burden of disease in chronic rhinosinusitis, but it was not meant to exclusively evaluate OD as it only has one item pertaining to it. The Questionnaire for Olfactory Disorders (QOD) is a patient-reported questionnaire that aids clinicians to assess the impact of olfactory impairment on quality of life <sup>22</sup> which has been proven to be a reliable and valid tool in numerous studies. It consists of two parts: statements and visual analogue scales (VAS). The statements explore three aspects, namely, patient's life quality (QOD-LQ), sincerity (QOD-S), and parosmia (QOD-P). The VAS make up the second part of QOD and give an insight into patient awareness of their olfactory disorder and the degree to which it adversely affects them. To the best of our knowledge, only one exploratory factor analysis (EFA) had been done on QOD. Mattos et al <sup>23</sup> extracted NS statements from the QOD, from which exploratory factor analysis revealed four factors, namely: social, anxiety, annoyance and eating related questions. By doing confirmatory factor analysis (CFA), we can determine the construct validity of the mQOD, which is how well the items measure the construct based on a priori model. In this case, the constructs were annoyance, anxiety, eating, social and sincerity.

Although loss of smell is not immediately life threatening, it impairs patients' quality of life in multiple aspects, from eating and cooking habits to affecting interpersonal relationships <sup>14</sup>. With advancement of medical knowledge and technology, we not only try to treat the patient's condition but also ensure that the patient's quality of life is preserved or improved. By translating the QOD into the Malay language, we hope to provide a validated tool that can be applied to Malaysians. The mQOD could be used as a tool to assess the severity of olfactory dysfunction and monitor symptom improvement.

#### 3.4 METHODS

#### **Research tool**

The latest English version of QOD was obtained from Johannes Frasnelli via email correspondence. It is made up of 29 statements and 5 VAS. The statements measure 3 main areas namely life quality (negative and positive statements, each denoted as QOD-NS and QOD-PS), sincerity and parosmia, each of them consisting of 19, 6 and 4 questions respectively. The answer for each statement is presented in a Likert scale with possible answers being "I disagree", "I disagree partly", "I agree partly" and "I agree". For each of the answer, the point assigned is 0, 1, 2, and 3 respectively, except for statements numbered 14, 23, 32, 25 and 36, where the inverse is true. The maximum raw score for the QOD-LQ is 57, with the formula to convert it to LQ score being LQ = LQraw score/0.57 (%). For QOD-S, the maximum raw score is 18 and the formula to convert it into the sincerity score is S = S raw score/0.18 (%). Lastly, the highest raw score for QOD-P is 12 and the formula for conversion is P = P raw score/0.12 (%). High scores for QOD-LQ and QOD-P indicate strong impairments and parosmia whereas a low score for QOD-S indicates that the patient may have given what they perceive to be socially acceptable answers. On the other hand, the VAS is a visual scale labelled "not at all" on the left side, denoting score 0 and "extremely annoying" on the right side, denoting score 10.

#### **Translation phase**

A forward translation into the Malay language was done by 2 native Malay speakers, a doctor experienced in management of smell disorders and a professional translator, who were proficient in Malay and English. Backward translation was done by another doctor with no knowledge of the original version of the questionnaire. The backtranslation was assessed for equivalence to the original English version by the panel, and a second draft was written. The word "accident" in P1 and P4 was substituted with "gangguan bauan" which is the Malay equivalent of OD.

Face validity was done by testing the second draft on 5 patients and 3 medical doctors who were fluent in Malay and English. Any ambiguity or confusion regarding the questions was considered and the feedback form of the mQOD reviewed. Finally, discrepancies between the original, forward translation version and the back-translated version were reviewed and reconciled to produce the final mQOD.

#### Sample

This was a cross sectional study, whereby subjects with self-reported altered smell were recruited via purposive sampling from the ORL clinic and wards of Hospital Universiti Sains Malaysia and Hospital Sungai Buloh. The period of recruitment was from April 2021 to April 2022. As per previous recommendation<sup>24</sup>, the target sample size was 300, with a ratio of nine subjects to one item. Considering a dropout rate of 20%, the final sample size was inflated to 375 participants. The inclusion criteria included those with impaired smell aged 18 years and above and were fluent in the Malay language. Patients with cognitive disturbance, speech and hearing difficulties were excluded. The patient information sheets and questionnaire were made available as both print outs and Google form links. The mQOD was administered again to the same participants at a seven-day interval.

#### **Data Analysis**

Data analysis was done using Statistical Package for the Social Sciences (SPSS) 28 and CFA was done using Analysis of Moment Structures (AMOS). Data from day one was analyzed for internal consistency and construct validity, whereas test-retest reliability was analyzed using data from day one and day seven. Internal consistency was measured using Cronbach alpha, with acceptable values ranging from 0.5-0.7 and good from 0.7-0.8 <sup>25</sup>. Test-retest reliability was determined with intraclass correlation coefficient (ICC), where  $\leq 0.5$  is poor, 0.5-0.75 is moderate, 0.75-0.9 is good and  $\geq 0.90$  is excellent reliability <sup>26</sup> Test-retest reliability analysis was done on 157 respondents without viral or post viral infections to ensure temporal consistency.

We created a five-factor model by adding a sincerity factor to the four-factor model suggested by a past study <sup>23</sup>. The remaining items of the questionnaire were distributed within the prespecified model. The factors and their items were as follows:

- i) Social related questions (SOC): q20, q21, q25, q26, q28, q29, VAS3, VAS4
- ii) Eating related questions (EAT): q1, q5, q7, q17, q24
- iii) Annoyance related questions (ANN): q2, q3, q4, q6, q8, q13, q22, VAS1, VAS2,VAS5
- iv) Anxiety related questions (ANX): q10, q12, q15, q16, q16
- v) Sincerity questions (SIN): q9, q11, q14, q18, q23 and q27.

The accepted factor loading was set at  $\ge 0.4^{27}$ . The following were parameters of good fit: CMIN/DF  $\le$ 5 comparative fit index (CFI) and Tucker-Lewis fit index (TLI)>0.9, root mean square error of approximation (RMSEA) <0.08 and standardized root mean square residual (SRMR) < 0.08 <sup>28</sup>. Convergent validity is measured by average variance extracted (AVE), which should be >0.50 <sup>29</sup>. Composite reliability (CR) is a measure of construct reliability, which was set at >0.7<sup>30</sup>. AVE and CR values were calculated following equations given by Fornell and Larcker <sup>31</sup>

#### Ethical approval

Ethical approval was obtained from the Universiti Sains Malaysia Research Ethics Committee and the Malaysian Medical Research and Ethics Committee.

#### 3.5 RESULTS

#### Demography

A total of 375 subjects were recruited for this study and out of these, 52 subjects dropped out and did not complete the questionnaire on day seven. Our sample was made up of 181 (48.3%) men and 194 (51.7%) women. The youngest subject was 18 years old and the oldest was 69 years old, with mean age of participants being 35.9. Almost half of the subjects had post viral infection including COVID (47.5%), followed by asthma, allergic rhinitis and or eczema (27.7%). Table 1 summarizes the subject demography.

#### Reliability

Cronbach's alpha coefficient was 0.537 for P, 0.891 for LQ, 0.637 for S and 0.865 for VAS. Overall internal consistency was good at 0.897. The ICC was 0.975, 0.979, 0.979 and 0.979 for P, LQ, S and VAS scores respectively. All items of each domains had ICC >0.9, except for question 5 and 17 >0.8, with p value <0.001. Table 2 and 3 summarizes the tests of reliability for mQOD.

#### Validity

Our data showed a poor fit with the five-factor model, and there were high factor correlations between ANN and EAT (0.801); and SOC and ANX (0.855). Therefore, these factors were combined, converting the model into a three-factor model. The following items with factor loadings <0.4 were deleted:

- i) q27: Sometimes I talk about things I do not understand
- ii) q2: Sometimes I think I can smell something bad, even when other people can't.
- iii) q3: Some of the smells that I find unpleasant, other people find pleasant.
- iv) q19: I can imagine adjusting to the changes in my sense of smell.
- v) q5: Because of the changes in my smell, I go to restaurants less often than I used to.

- vi) q4: One of my biggest problems is that smells smell different to what they used to before my accident.
- vii) q17: Because of the changes in my sense of smell I have weight problems.
- viii) q11: Sometimes I have thoughts and ideas I would not want other people to know of.
- ix) q15: Because of the changes in my sense of smell I visit friends, relatives, or neighbors less often.

Three covariances were made based on the modification indices, which were as follows:

- VAS1 (Rate how annoying the changes in smell are) and VAS2 (Rate how often you become aware of the changes to your sense of smell)
- ii) VAS2 (Rate how often you become aware of the changes to your sense of smell.) and q6 (I am always aware of the changes in my sense of smell)
- q7 (Because of the changes in my sense of smell, I don't enjoy drinks or food as much as I used to) and q13 (The changes in my sense of smell annoy me when I am eating)

Nine items with Standardized Residual Covariance (SRC)  $\geq 2$  were removed, which were q1, q25, VAS5, q26, q29, q16, q20, q12 and q18. The final three-factor model with a total of 15 items had acceptable model fit with CMIN/DF=3.332, TLI=0.923, CFI=0.939, RMSEA=0.079 and SRMR=0.0574. Table 4 shows fit statistics for the five and three-factor models while figure 1 and 2 shows the diagram of the models.

The remaining items had factor loadings between 0.490 to 0.883. The CR for all factors were > 0.7, and AVE was 0.627 for ANN, 0.454 for SIN and 0.431 for ANX. The correlations between ANN and SIN was 0.02, between SIN and ANX was -0.40, and between ANX and ANN was 0.59.

#### **3.6 DISCUSSION**

Since its conception in 2005, the QOD has been translated into multiple languages and proven to be valid and reliable in numerous studies. In this study, we aimed to test the validity and reliability of the mQOD so that it can be applied to the majority Malayspeaking population in Malaysia. The mQOD can also be a useful tool in the clinical setting to assess the burden of disease in patients and monitor treatment response.

In our study, the gender distribution was almost equal, however women had higher mean scores in LQ, P and VAS domains. This finding is consistent with other studies <sup>32,33</sup>, suggesting that women are more affected by smell impairment. The mean scores for all domains also reduced on day seven, indicating improvement in symptoms. Our results show that LQ statements and VAS components had good internal consistency with Cronbach alpha being 0.891 and 0.865. On the other hand, the Cronbach alpha for P and S statements were 0.545 and 0.637 respectively, which is considered acceptable. Similarly, the Turkish, Korean and Persian translations of the QOD also show lower Cronbach alpha for S statements at 0.62, 0.243 and 0.25 respectively <sup>34–36</sup>. The S statements were initially designed as a measure of the subject's credibility <sup>22</sup> and although this scale might be relevant in psychological studies, these statements may be omitted in a clinical setting for the sake of time efficiency as their removal does not alter the overall internal consistency much. The Chinese equivalent of QOD also display low internal consistency for P statements at 0.473, citing cultural differences <sup>37</sup>. The other reasons for this could be to low number of items or poor interrelation between items.<sup>38</sup>. This poor interrelation is supported by the fact that when P1 statement (Food tastes different than it used to) was removed, it increased the Cronbach's alpha of the P domain to 0.757.

In test-retest studies, the time frame needs to be long enough so the participants would not recall the test items but short enough so there would not be changes in their condition <sup>39</sup>. Other studies have reported intervals between two weeks and up to 12 months in between the test periods <sup>33,34,37,40,41</sup>. In our study, the mQOD was readministered after a seven-day interval. The ICC for domain scores and their items were all excellent, indicating that the mQOD is a reliable measure. Our findings echo that of Lechien et al <sup>41</sup> which had excellent test-retest reliability, except for the S domain. The anglicized version of QOD displayed moderate to good agreement measures ranging between 0.68 to 0.78 <sup>33</sup>. Likewise, Yang et al <sup>37</sup>also showed good correlation in all domain scores except for VAS.

Our data fit poorly into the initial five-factor model. Assessment of model fit revealed several factors that were highly correlated, which were later combined. Factor SOC and ANX was combined as they were both measuring anxiety, whereas the common latent variable underlying ANN and EAT was annoyance. Error covariances were made based on modification indices to improve model fit. VAS1 and VAS2 were worded similarly, whereas q6 and VAS2 both measure the frequency with which the subject realized their olfactory impairment. Lastly, q17 and q13 both explores the impact of OD on their eating experience. Although arguments have been made against post hoc error term correlations<sup>42,43</sup>, some still consider it legitimate in similarly worded test items <sup>44</sup>. Although the AVE for SIN and ANX were <0.5, their CR is >0.7 which demonstrates acceptable convergent validity<sup>45</sup>. The factor correlations were <0.85, which shows good discriminant validity<sup>28</sup>. This means that the latent variables are unrelated and measuring distinct constructs.

There are several limitations of this study. The subjects were recruited on the basis of self-reported olfactory impairment and no objective smell evaluation was done. Therefore, we were unable to verify if all subjects did have OD. Furthermore, due to the COVID-19 pandemic, there was also a disproportionate number of subjects with post viral infection which could implicate the generalizability of the study findings. In the future, another validation study should be done on a new sample set as more than 20% of the original items have been deleted<sup>46</sup>.

#### **3.7 CONCLUSION**

The mQOD is a valid and reliable tool to measure smell impairments.

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