# A Critical Review & Experimental Study:

Auditory Perception and Quality of Life in Female Tracheoesophageal Speakers

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This objective of this paper was to examine the relationship between listener-rated auditory-perceptual outcomes and self-rated quality of life (QOL) in female tracheoesophageal (TE) speakers. Study 1 sought to critically appraise the current research addressing this relationship in alaryngeal speakers. Study 2 sought to examine this relationship by analyzing naïve listeners' speech acceptability and listener comfort ratings and voice-related Quality of Life (V-RQOL) in female TE speakers (n=15). Outcomes from both studies revealed no relationship between auditory-perceptual judgements of speech and voice-related QOL. These results suggest that female TE speakers' self-perceptions of V-RQOL are not shaped by or consistent with listener-rated outcomes.

## *Introduction*

Total laryngectomy (TL) is a primary treatment for those with laryngeal cancer (Terrell, Fisher & Wolf, 1998) and it results in the loss of the normal voice production. Consequently, those who undergo TL must acquire new, non-normal "alaryngeal speech" methods of voice and speech production. The negative impact of TL on quality of life (QOL) has been well documented (Eadie, 2007; Evitts, Kasapoglu, Demirci & Miller, 2011; Op de Coul et al., 2004; Robertson, Yeo, Dunnet, Young & MacKenzie, 2012). Furthermore, Robertson and colleagues (2012) identified that the loss of laryngeal speech has the most negative impact on QOL in laryngectomized individuals.

The unique communication challenges faced by this population also have negative social implications (Eadie & Doyle, 2004). Listener rated auditory-perceptual measures have been used to estimate the social penalty of alaryngeal speech (Eadie et al., 2012). In addition, some researchers have investigated the relationship between listener judgments of various features of voice quality and self-rated QOL after total laryngectomy. These investigations have employed discipline-specific QOL tools that are designed to measure the influence of head and neck cancer on functioning, as well as discipline-specific QOL measures of voice-related function.

## *Objectives*

The purpose of Study 1 is to critically appraise this research and to determine, which, if any, listener-rated outcomes are correlated with QOL in alaryngeal speakers. Study 2 examines the relationship between listener-rated outcomes and participants' self-rated Voice-Related Quality of Life (V-RQOL) in female tracheoesophageal speakers.

## ***Study 1: Critical Review***

## *Methods*

Search Strategy

Computerized databases including PubMed, PsychINFO, Medline-Ovid, and ProQuest Nursing & Allied Health Source as well as ASHA publications were searched using the following search strategy: ((((("perceptual/acoustic"[Title/Abstract]) AND quality of life [Title/Abstract]) AND laryngectom* [Title/Abstract]) OR alaryngeal [Title/Abstract]) OR tracheoesophageal [Title/Abstract]). Reference lists from articles obtained by this search strategy were used to obtain additional relevant articles.

Selection Criteria

Studies included in this review were required to measure listener-rated perceptual outcomes of alaryngeal speech, the speakers' self-rated QOL, and the potential relationship between the two in alaryngeal speakers.

Data Collection

The search strategy employed yielded four peer-reviewed original articles meeting the selection criteria. These articles were all cross-sectional studies, Level 3 evidence (CSD 9639) including: Meyer, Kuhn, Campbell, Myers & Layde (2004); Eadie, Day, Sawin, Lamvik & Doyle (2012); Law, Ma & Yiu (2009); Eadie & Doyle (2004).

## *Results*

**Meyer et al. (2004)** explored the relationship between speech intelligibility and QOL in five-year head and neck cancer survivors (n=62), and of relevance here, 16 who had undergone TL. Among

the laryngectomy subgroup, speech methods included: tracheoesophageal (TE) (n=6), esophageal (ES) (n=3) and electrolaryngeal (EL) (n=7). Participants completed both sentence and word intelligibility measures and disease-specific QOL ratings using valid and reliable tests and questionnaires commonly employed for these purposes. Three experienced speech-language pathologists rated the speech samples following a standardized protocol. Significant positive associations were found between word and sentence intelligibility, and self-perceived QOL related to speech and understandability of speech. These results were found with appropriate correlations for the full participant group, but not when the laryngectomy group was considered alone. This latter finding may be due to the small group size.

One limitation of this study was the lack of detail regarding participant demographics for each subgroup (laryngectomy vs. others) and specifically the number of females and time postsurgery. The procedures employed in this study were well described and appropriate. However, the use of experienced listeners could have resulted in higher estimates of intelligibility, and, therefore, may limit generalization of the results.

Overall, this study provides suggestive evidence that experienced listener-rated word and sentence indelibility are positively correlated with QOL in head and neck cancer patients, but equivocal evidence for this relationship in those with TL.

**Eadie et al. (2012)** investigated the relationship between listener-rated intelligibility, acceptability, and two self-rated QOL measures in alaryngeal speakers. This cross-sectional study included 25 laryngectomized individuals (5 females) using TE speech (n=16), ES speech (n=2) and EL speech (n=7), all at least one year postlaryngectomy. The demographics of the participants are representative of the laryngectomy population. Participants completed standard speech measures, as well as a disease-specific QOL measure and a discipline-specific QOL measure in order to determine if a stronger relationship existed with either of these scales. Thirty-three naïve listeners rated intelligibility following standardized protocols. A second group of 15 listeners made judgements of acceptability on a 100mm visual analogue scale. Acceptable intrarater reliability calculated on 20% of samples was reported.

Listener-rated acceptability and intelligibility were moderately correlated. Furthermore, speech acceptability was more predictive than intelligibility of QOL scores, although this relationship was weak to moderate. The only statistically significant (moderate) relationship was between listener-rated speech acceptability and speech on the disease-specific QOL measure.

Strengths of this research include participant procedures and the inclusion of two QOL measures designed to be sensitive to voice-specific and disease-specific changes.

Results from this study provide evidence that an individual's own assessment of his or her speech performance (as seen on QOL) is more related to how one's speech sounds different from that which is expected (speech acceptability) than to the actual understandability of speech (intelligibility) by the communication partner. In other words, speech performance does not match perceived satisfaction with voice.

**Law et al. (2009)** conducted a cross-sectional study to look at the relationships among intelligibility, acceptability and self-rated communication QOL in 56 Cantonese-speaking laryngectomized individuals (4 females, 6mos-16yrs postsurgery). The participants included individuals using four types of alaryngeal speech: TE (n=13), ES (n=7), EL (n=14), and pneumatic device (PD) (n=15). All participants were assumed to have reached their maximum proficiency in their respective speech mode as they had stopped regularly attending speech therapy clinics. The authors note that although only 4 females were included in this study, that this proportion is representative of the distribution of sex of the alaryngeal-speaking population in Hong Kong. Participants completed speech measures and communication activity and participation measures commonly employed in this research. Six listeners divided into two groups (younger: n=3, age 25-33 yrs; older: n=3, age 60-65 yrs) transcribed the speech samples in order to obtain an intelligibility score; they also rated the acceptability of the speaker's voice on an 11-point equal-appearing interval (EAI) scale. Appropriate intrarater reliability was calculated on 80% of speech samples two weeks later.

Appropriate statistical analysis revealed significant differences between the older and younger judge groups, with the younger group making judgements of higher intelligibility, and less acceptable speech, indicating that these two listener-rated speech outcomes are viewed differently depending on the listener's age. Overall, the ES and EL speakers were judged to have poor speech intelligibility and lower

QOL, although correlational analysis of the data was not reported. PD speakers had the highest speech intelligibility and acceptability, but TE speakers had the highest QOL. However, although a difference in QOL was observed between TE and PD, it was not statistically significant.

It is important to consider that listener groups were small (n=3); a larger number of listeners would have given these results more power. The application of these findings to alaryngeal speakers of non-tonal languages also is a limitation of this study.

These results of this research suggest a relationship between intelligibility, acceptability, and QOL in alaryngeal speakers, however, no statistical analysis was performed. Findings offer some evidence that listener age affects intelligibility and acceptability ratings.

**Eadie & Doyle (2004)** examined listeners' auditory-perceptual ratings of TE voice, the TE speakers' self-rated QOL and the relationship between the two. In order to better understand the potential for social penalty, speech samples from 28 TE speakers (6 female), who were at least 12 months postlaryngectomy, were evaluated for overall speech severity, naturalness, acceptability and pleasantness. Measures of speaker's self-rated QOL were taken using disease-specific measures typically employed. Fifteen naïve listeners rated speech samples on the four perceptual dimensions using direct magnitude estimation procedures.

Appropriate statistical analysis revealed that male TE speakers were judged to have significantly better, more natural, pleasant, and acceptable voices than female TE speakers. However, no statistically significant differences in QOL scores were found between male and female speakers. When considering all participants, appropriate statistical analysis revealed that naturalness was moderately correlated to communication scores on the QOL.

Strengths of this study include listener procedures, reliability, and validity of judgements. Limitations include the number of female participants and the use of a disease-specific QOL measure, which may not be sensitive for measuring speech and voice outcomes (Op de Coul et al., 2004).

Results suggest that lower listener-rated outcomes of TE speech do not necessarily translate into lower QOL for females. However, the number of female on which to base these conclusions limits the external validity of this finding. Data provided suggests a moderate relationship between listener-rated "naturalness" and communication QOL.

### *Discussion*

The current research provides evidence that suggests measures of acceptability are more predictive of QOL than intelligibility (Eadie et al., 2012; Law et al., 2009) and that speech acceptability and naturalness are moderately correlated to speech on disease-specific QOL instruments (Eadie et al., 2012; Eadie & Doyle, 2004). Given the limitations of the research to date, specifically in relation to providing evidence based on female voice, further research in this area is warranted.

## ***Study 2: Experimental Study***

### *Rationale*

The current study sought to elucidate a potential relationship for which there is no compelling evidence to date. It is possible that several factors such as voice specific QOL measures and participant demographics have limited the ability of researchers to capture any association between listener auditory perceptual judgements and self-perceptions of alaryngeal speakers.

The moderate relationships of listener-rated outcomes and self-rated QOL in the current literature may have occurred because listener-rated outcomes measure unique constructs not captured on QOL measures (Eadie et al., 2012). It is, therefore, possible that this relationship is masked due to the lack of specificity of the measures of QOL employed. QOL is multidimensional and reported scores may sometimes mask concerns in specific areas (e.g., a high score in one domain combined with low score in another domain may limit overall scores for QOL measures). In addition, disease-specific QOL questionnaires are insufficient for measuring speech and voice outcomes (Op de Coul et al., 2004). Even when Eadie et al. (2012) investigated this relationship using discipline-specific QOL measures, they found no significant relationship. However, in that particular study many groups of alaryngeal speakers were included which may have affected the sensitivity of the results. For this reason, the current study will examine TE speakers only using the Voice-Related Quality of Life (V-RQOL), a discipline-specific instrument (Hogikyan & Sethuraman,1999).

Furthermore, Eadie and Doyle (2004) provided evidence to suggest that females are differentially penalized on listener-rated outcomes. Other research has confirmed these results (Eadie, Doyle, Hansen & Beaudin, 2008; Searl & Small, 2002). The impact of

this finding on QOL warrants investigation. In order to better understand this relationship in laryngectomized females, only female speakers will be included in this study.

## *Methods*

The present study was approved by the Ethics Review Board, Western University, London, Ontario, Canada.

### Speakers

Fifteen female TE speakers served as participant speakers for this study. All data including participant demographics, voice/speech samples and V-RQOL measures had been previously collected. At the time of data collection, speakers were on average 39.80 months post TL (SD = 39.81 months; range = 6 months-11years, 9 months). The average age was 64.93 years (SD = 9.71 years; range = 43-79 years).

These 15 speech samples of one sentence of the Rainbow Passage (Fairbanks, 1960) were randomized into 3 different lists. Twenty percent of samples (n=3) were randomly selected and repeated at the end of each list for reliability purposes.

### Listeners & Listening Procedures

*Part 1*

Five women (mean age 25.70 years) were recruited from the speech-language pathology graduate program at Western University, London, Ontario, to serve as experienced listeners for the gender rating protocol. These listeners rated the gender of all speech samples using a 100mm visual analogue scale of masculinity-to-femininity that was adapted from Searl and Small (2002). Listeners were blind to the gender of the speakers.

*Part 2*

Thirty-two naïve individuals were recruited from undergraduate and graduate programs at Western University to serve as naïve listeners to perform judgements of speech acceptability (ACC) and listener comfort (LC). One participant's data was excluded from further analyses due to an error in task instruction. The remaining 31 participants (19 women, 12 men, mean age, 24.80 years) served as listeners. These listeners rated ACC and LC of the same 15 speech samples on 100mm visual analogue scale. However, prior to making rating of the 15 experimental samples, listeners were presented with four samples of TE speech that were not included in the randomized list in order to expose them to the unique characteristics of alaryngeal voice. Second, the listeners were instructed on the task and familiarized with the definition of both LC and speech ACC. For ACC, the instructions given to the listener were as follows:

*"In making your judgments about the speakers you are about to hear, give careful consideration to the attributes of pitch, rate, understandability, and voice quality. In other words, is the voice pleasing to listen to, or does it cause you some discomfort as a listener?"* (Bennett & Weinberg, 1973, p. 610).

LC was described as:

*"How comfortable would you feel listening to the person's speech in a social situation? Your rating should reflect your feelings about the way the person was speaking, not what the person was saying or how their personality affected you"* (O'Brian et al., 2003, p. 509).

Before starting the auditory-perceptual judgment task, listeners were informed they were listening to speech samples provided by female speakers. Presentation of rating tasks (ACC and LC) was counterbalanced to reduce the potential order effects.

### Data Analysis

Relationships were calculated using Pearson correlation coefficients between auditory-perceptual ratings by naïve listeners, between gender ratings from experienced and auditory-perceptual ratings by naïve listeners, and between auditory perceptual measures and V-RQOL data (social-emotional, physical, and total scores).

## *Results*

### Listener Agreement

Listener agreement was calculated between first and second ratings of the three repeated samples for each listener on both judgement tasks (e.g. LC and ACC). The percentage of ratings which fell within 5mm, 10mm, 15mm, and greater than 15mm of the original rating was calculated. Fifty-three percent of the experienced listeners' ratings fell within 5 mm, 26.67% with 6-10 mm, and 20.00% were greater than 15 mm from original sample ratings.

For the naïve listeners, agreement for ACC was: 48.4% within 5mm, 19.4% 6-10mm, 15.0% 11-15mm, and 17.2% were greater than 15mm difference. For LC, 44.1% of repeated measures were within 5mm, 22.6% 6-10mm, 11.8% 11-15mm, and 21.5% were greater than 15mm.

### Gender Ratings

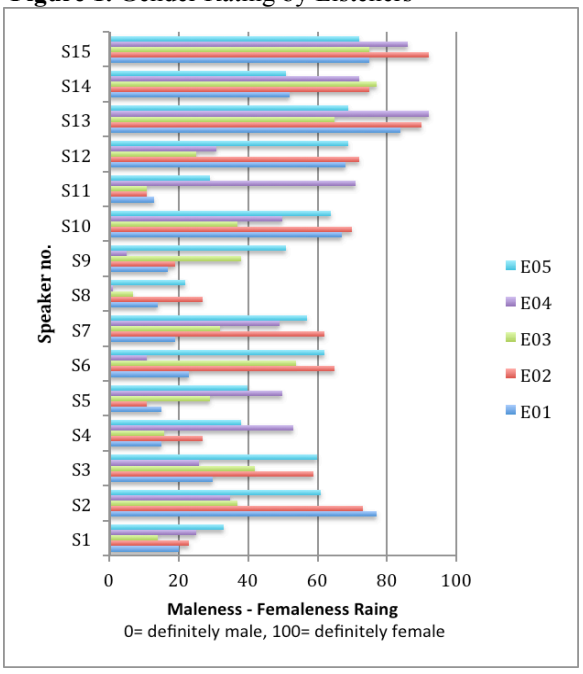
Table 1 reports the average rating by speaker of the masculinity-to-femininity judgements performed by

the experienced listeners. Figure 1 graphically presents agreement between listeners for each speaker.

**Table 1.** Gender Rating by Speaker

| Speaker no. | Average Gender Rating |
|---|---|
| 13 | 80 |
| 15 | 80 |
| 14 | 65.4 |
| 10 | 57.6 |
| 2 | 56.6 |
| 12 | 53 |
| 7 | 43.8 |
| 3 | 43.4 |
| 6 | 43 |
| 4 | 29.8 |
| 5 | 29 |
| 11 | 27 |
| 9 | 26 |
| 1 | 23 |
| 8 | 14.2 |

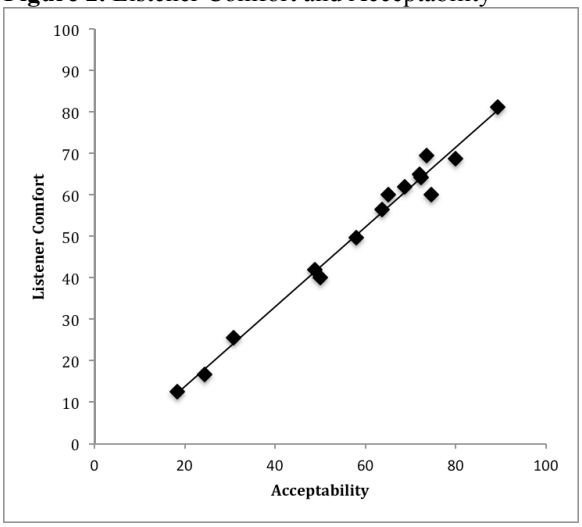
**Figure 1.** Gender Rating by Listeners




Auditory-Perceptual Measures

The mean for the ACC ratings across all speakers was 59.31 (SD = 20.93; range = 18.29-89.37); for LC, the mean was 51.51 (SD = 20.27; range = 12.48-81.19). Listener's ratings of ACC and LC were found to be highly and significantly correlated (r=0.99, P < .05) and these data are shown in Figure 2. Of note, there was a statistically significant difference between men and women's ratings for ACC (P < 0.05) with women indicating more penalty (lower rating) than men. No significant difference between men and women's ratings of LC was found

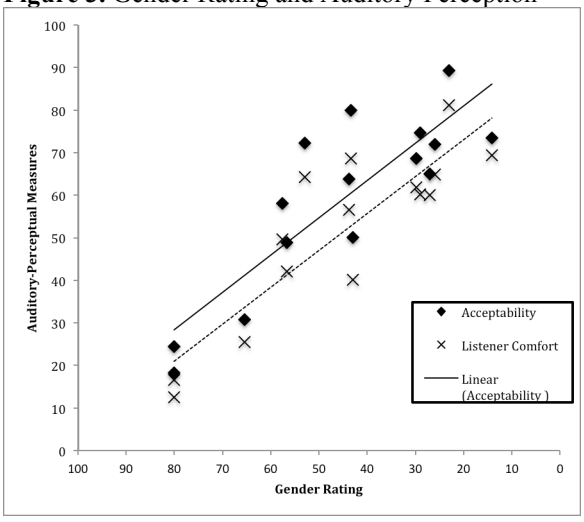
**Figure 2.** Listener Comfort and Acceptability




Relationship between Auditory-Perceptual Measures and Gender Ratings

The relationship between the naïve listeners' auditory-perceptual judgements and those of the experienced listeners' gender ratings for the 15 TE speakers is reported in Figure 3. ACC was found to be significantly correlated to gender ratings (r= 0.86, P < .05), as was LC (r= 0.87, P < .05).

**Figure 3.** Gender Rating and Auditory Perception




V-RQOL Scores

The mean total V-RQOL score for all speakers was 69.17 (SD = 19.57; range = 45.00-95.00). The mean score on the Social-Emotional domain was 75.42 (SD = 26.07; range = 6.25-100), and on the Physical-Functioning domain was 65.00 (SD = 18.50; range = 33.33-91.67).

Relationships between Auditory-Perceptual Measures and V-RQOL Scores

No significant relationships were found between auditory-perceptual measures and the V-RQOL scores (social-emotional, physical-functioning or total V-RQOL score). Correlations for male and female listeners were done separately. This information is detailed in Table 2.

### *Discussion*

Findings from this study provide evidence to suggest that LC and ACC of female TE speech are highly correlated. In addition, judgements of LC and ACC are significantly related to gender ratings of experienced listeners. However, the lack of relationship between auditory-perceptual judgements of speech and V-RQOL suggests that female TE speakers' self-perceptions of V-RQOL are not shaped by or consistent with listener-rated outcomes.

## ***General Discussion***

A critical analysis of the existing literature examining the relationship between listener-rated outcomes and self-rated QOL has included the use of a range of auditory-perceptual measures. Meyer et al. (2004) investigated intelligibility and found no statistically significant relationship. These findings were confirmed by research by Law et al. (2012) and Eadie et al. (2012) though both these authors also examined ACC. Eadie et al. (2012) found a statistically significant moderate relationship between intelligibility and ACC. Law et al. (2012) also described a relationship, although their analysis reveals that this relationship appears to shift with age of the listener. Other research by Eadie and Doyle (2004) employed measures of naturalness, pleasantness and overall severity in addition to ACC.

Interestingly, Eadie and Doyle (2004) found a significant correlation only between naturalness and QOL, where Eadie et al. (2012) found a relationship to QOL when ACC was used. These findings are consistent with data reported by Law et al. (2012), although a statistical analysis was not performed to confirm the significance of the relationship.

The present experimental study employed auditory-perceptual measures of ACC and LC. The mean ACC ratings of female speakers in the experimental study were within 1 SD of the mean ACC value for female speakers included in the earlier study conducted by Eadie and Doyle (2004). The difference observed between men's and women's ratings of ACC have not been reported in additional literature to date. Research examining LC with alaryngeal speech has yet to be published, however, this study provides evidence that LC is highly correlated to ACC.

Taken together, the current literature on TE speakers revealed that ACC and naturalness are significantly and moderately correlated to speech as measured on disease-specific head and neck cancer QOL instruments (Eadie et al., 2012; Eadie & Doyle, 2004). Eadie et al. (2012) hypothesised that a stronger relationship might be captured with the use of a voice-related QOL, but this hypothesis was not confirmed. When female TE speakers were considered alone in the current empirical study, no relationship between listener-rated ACC or LC and V-RQOL was found.

The present study sought to address some of the limitations of the current literature to capture a relationship between listener auditory-perceptual ratings and self-rated outcomes, and to address this relationship in female TE speakers. A limitation of the present study was the age of listeners, as no older listeners were included. However, given the results provided by the literature taken as a whole, it is unlikely that the inclusion of an older listening group would have provided significant relationships in the experimental study.

## ***Clinical Implications***

Findings from Study 2 suggest listener auditory-perceptual ratings and self-rated outcomes of female TE speakers measure two different aspects of functioning. These findings are congruent with the research on female TE speakers examined in Study 1. Implications of this research indicate that poorer judgements by listeners do not necessarily translate to worse V-RQOL scores. Further research on what impacts QOL in female TE speakers is needed. At a minimum, however, the current data provide information that may assist counseling in this unique population.

### *Acknowledgements*

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**Table 2.** Pearson Correlation Coefficient and Significance of Relationships between Auditory-Perceptual Dimensions and V-RQOL

| | | Female-rated ACC | Male-rated ACC | Female-rated LC | Male-rated LC | VRQOL Social-Emotional | V-RQOL Physical-Functional | V-RQOL Total |
|---|---|---|---|---|---|---|---|---|
| Female-rated ACC | Pearson Correlation | 1 | .960** | .983** | .994** | -.170 | -.128 | -.163 |
| | Sig. (2-tailed) | | .000 | .000 | .000 | .545 | .648 | .561 |
| | N | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Male-rated ACC | Pearson Correlation | | 1 | .965** | .964** | -.152 | -.008 | -.086 |
| | Sig. (2-tailed) | | | .000 | .000 | .589 | .977 | .761 |
| | N | | 15 | 15 | 15 | 15 | 15 | 15 |
| Female-rated LC | Pearson Correlation | | | 1 | .980** | -.159 | -.090 | -.136 |
| | Sig. (2-tailed) | | | | .000 | .571 | .749 | .629 |
| | N | | | 15 | 15 | 15 | 15 | 15 |
| Male-rated LC | Pearson Correlation | | | | 1 | -.191 | -.133 | -.177 |
| | Sig. (2-tailed) | | | | | .495 | .637 | .528 |
| | N | | | | 15 | 15 | 15 | 15 |
| V-RQOL Social-Emotional | Pearson Correlation | | | | | 1 | .653** | .903** |
| | Sig. (2-tailed) | | | | | | .008 | .000 |
| | N | | | | | 15 | 15 | 15 |
| V-RQOL Physical-Functional | Pearson Correlation | | | | | | 1 | .915** |
| | Sig. (2-tailed) | | | | | | | .000 |
| | N | | | | | | 15 | 15 |
| V-RQOL Total | Pearson Correlation | | | | | | | 1 |
| | Sig. (2-tailed) | | | | | | | |
| | N | | | | | | | 15 |

**Correlation is significant at the 0.01 level (2-tailed).

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