OBJECTIVE. We explored the relationships between sensory modulation and health-related quality of life (HRQOL), social supports, and mental health symptoms of anxiety and depression.

METHOD. Twenty-eight adult volunteers ages 18–60 participated in the study. Fourteen adults were sensory overresponsive (SOR), and 14 adults in a matched comparative group were not sensory overresponsive (NSOR). All participants were tested using self-administered measures of sensory processing.

RESULTS. Significant differences were found between SOR and NSOR groups on symptoms of anxiety, depression, and 4 of 8 indicators of HRQOL.

CONCLUSION. Several analyses exploring the relationships among the variables tested suggest that sensory response style, whether comparing SOR and NSOR groups or exploring the correlation of the response quadrants of the Adolescent/Adult Sensory Profile, appears significantly and differentially related to symptoms of affective mental health and quality-of-life indicators, including social participation.

Sensory modulation is the neurological regulation of the response to sensory stimuli. Sensory modulation disorder (SMD) occurs when behavioral responses are not graded in a way that is consistent with the situational demand and the range of emotional and attention responses cannot be appropriately graded. Sensory overresponsiveness may occur in one or multiple sensory systems. Emotional, illogical, or inconsistent responses are automatic unconscious responses (Miller, Anzalone, Lane, Cermak, & Osten 2007) related to sympathetic nervous system activation (Mangeot et al., 2001). The association between SMDs, specifically sensory overresponsive (SOR) type, and mental health issues such as anxiety, depression, social–emotional issues, autonomic nervous system reactivity, and coping strategies (Jerome & Liss, 2005; Kinnealey & Fuiek, 1999; Liss, Timmel, Baxley, & Killingsworth, 2005; McIntosh, Miller, Shyu, & Hagerman, 1999; Miller et al., 1999; Pfeiffer, Kinnealey, Reed, & Herzberg, 2005) have been reported in the literature specific to the adult population. Adults who are overresponsive to environmental stimuli appear to experience everyday life very differently from other adults. They describe their daily experiences as irritating, overwhelming, disorganizing, and distracting. They spend an inordinate amount of time coping with their responses to environmental stimuli, a situation that leaves them feeling exhausted and frequently isolated (Kinnealey, Oliver, & Wilbarger, 1995; Oliver, 1990). This isolation can affect their ability to fully participate and engage in the usual range of everyday occupations (Kinnealey et al., 1995; Pfeiffer, 2002). Poorer social skills and community activity and involvement have been found to be correlated with increased sensory sensitivity (Pfeiffer et al., 2005). This finding raises the larger question of the relationship among SMDs, social supports, and health-related quality of life (HRQOL).
Although the SMD most frequently addressed is SOR, described initially by Ayres (1979) as sensory defensiveness, other SMDs have been identified more recently, including low registration and sensory seeking (Ayres, 1979; Dunn, 2001). It is therefore important to differentially explore the relationship of modulation disorders with indicators of HRQOL. The isolation described as a coping strategy by adults with SMD also deserves further study because it has long been identified as a factor related to HRQOL. Information clarifying the relationship among these constructs could help therapists anticipate and mitigate the impact of SMD on mental health and quality of life.

SMD–SOR type has been described as a neural processing disorder that affects the modulation of sensory input and results in overreaction to otherwise harmless stimuli (Ayres, 1979; Miller et al., 2007). People who overrespond to these sensations demonstrate an avoidance or withdrawal from the stimuli. These flight-or-fright responses may reflect an activation of the sympathetic nervous system (Lane, Miller, & Hanft, 2000) and may include overresponsiveness to touch, sound, visual stimuli, and movement. The impact of SOR on behavior and school function has been explored with children, and a conservative estimate indicates that 5% of the pediatric population has severe under- or over-responsiveness to sensory stimulation (Ahn, Miller, Milberger, & McIntosh, 2004). Estimates for the adult population may well be similar.

SMD and its social and emotional implications were studied by Kinnealey et al. (1995), who explored the subjective reality of adults with sensory defensiveness and their coping strategies. In their phenomenological study, a conceptual model was proposed for further study. A second study of 32 adult volunteers, 16 with and 16 without sensory defensiveness, matched for age and gender, found that the sensory defensive group had significantly more symptoms of anxiety, depression, and social-emotional issues (Kinnealey & Fuiek, 1999). In a follow-up study, Pfeiffer and Kinnealey (2003) found a significant change in sensory defensiveness and anxiety in response to intervention in 15 adults with defensiveness. Pfeiffer, Kinnealey, Reed, and Herzberg (2005) found significant correlations between anxiety and sensory defensiveness and between depression and hyposensitivity in adolescents with Asperger syndrome. A significant inverse relationship was found between depression and the adaptive skills of leisure and social skills. Sensory hypersensitivity was found to be related to decreased community use and social skills. A single case study by Pfeiffer (2002) depicted sensory issues as having a lifelong impact on functions such as self-care, social participation, and occupational choice. The findings of these studies raise the question of the relationships and potential impact among sensory modulation issues, social supports, and participation and quality of life in general. Insight into these interrelationships could help with understanding the scope of issues and reframing interventions.

HRQOL is currently conceptualized as having two principal components: mental and physical. It is proposed that a third component is participation (e.g., a person’s ability to perform his or her social role). Participation is recognized as primary in HRQOL (Ware, 2003). The critical importance of role participation is supported by the International Classification of Functioning, Disability and Health (WHO, 2001), which supports and emphasizes the usefulness of measuring the health domain of participation.

The construct of social support has HRQOL implications for people with disabilities or conditions that affect their overall functioning. Social support is proposed to affect the etiology of some diseases by influencing lifestyle and self-esteem, or it may affect a person’s self-appraisal of a problem and ability to solve it. Social support, moreover, can mitigate the negative effects of some life situations by expanding coping ability and options (Brownell & Shumaker, 1984). Social support in this study encompasses emotional and informational support, tangible support, affectionate support, and positive social interaction, as delineated by the widely used Medical Outcomes Social Support Survey (MOS; Sherbourne & Stewart, 1991).

The first purpose of this study was to explore the differences in social support and HRQOL between a group of adults with SMD–SOR and a matched non-SOR (NSOR) group as well as the relationships between these variables. A second purpose was to explore whether symptoms of anxiety and depression and indicators of HRQOL are significantly related to sensory response styles as described in Dunn’s (2001) Sensory Processing Model.

Research Questions

1. Are there statistically significant differences between adults with SOR and those without SOR on symptoms of anxiety and depression, perceived social supports, and HRQOL indicators?

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1The terminology for this phenomenon has evolved to the currently used SMD–SOR type but has been referred to in previous literature as sensory defensiveness or hypersensitivity. The terms used in this article reflect the cited studies.
2. Are there statistically significant correlations between scores of sensory modulation, symptoms of anxiety and depression, perceived social supports, and HRQOL indicators?

3. What is the relationship between the four sensory processing styles identified in the Adolescent/Adult Sensory Profile (AASP; Brown & Dunn, 2002) and the eight HRQOL indicators?

Method

Setting
The study took place in an urban university setting in the occupational therapy research suite. Participants were recruited from the metropolitan and surrounding suburban areas. Participants were contacted by phone, the study was explained to them, and an appointment to come to the facility at their convenience was made.

Participants
The research was approved by the institutional review board of Temple University, and all participants completed a consent form before enrolling in the study. Participants were recruited through (1) flyers placed in occupational therapy private practice settings, (2) networking through the occupational therapy community, and (3) an article in a professional newsletter requesting participation in a study of SOR in adults. Inclusion criteria for participants included (1) age ≥18 yr, (2) no history of physical or sexual abuse, (3) no history of a clinically diagnosed mental health condition, (4) absence of confounding medical conditions, and (5) normal intelligence. Symptoms of SMDs are reflected in several mental and physical diagnoses, and it was therefore important to identify adults with SOR but without clinical diagnoses.

Instruments
All participants were asked to complete self-report instruments that assess sensory processing, HRQOL, social supports, and mental health indicators.

Sensory Processing. The Adult Sensory Questionnaire (ASQ; Kinnealey et al., 1995) is a 26-item true–false questionnaire used as a screening tool to determine whether an adult is sensory defensive. The statements are indicative of sensory sensitivity. A response of true is scored 1, and a response of false is scored 0. A score ≥10 is an indication of SOR. Participants in the study who scored >10 were placed in the sensory defensive group. The validity of screening for group placement using the ASQ was supported by the high correlations ($r = .83$, $p > .01$) between the scores on the ASQ and the AASP SOR identified as score defensive, defined as a sum of the sensory sensitivity and sensory-avoiding score. Strong correlations were also reflected between the ASQ, the Sensory Profile, and the Adult Sensory Interview (ADULT–SI; Kinnealey & Oliver, 2010), a scored interview format used to further describe the SOR group. The AASP (Brown & Dunn, 2002) is a 60-item self-report scale designed to measure (1) sensory processing, including SOR (sensory avoiding and sensory sensitivity), which indicates a low threshold to sensory stimuli, and (2) underresponsiveness (low registration and sensory-seeking behaviors), which indicates a high threshold for responding to sensory input. Low-threshold items may be added together to produce an SOR score (sensory sensitivity [SS] quadrant score + sensory-avoiding [SA] quadrant score identified the SOR group). The ASQ screens for SOR and is highly correlated with SS ($r = .825$, $p = .0001$), SA ($r = .797$, $p = .0001$), and the SOR score ($r = .833$, $p = .0001$). Therefore, it is a valid and appropriate tool to use in screening for group placement.

Assessment Tools for Social Supports, Quality of Life, Anxiety, and Depression. The MOS is a brief, 19-item, self-report instrument that measures perceived availability of social support. Multitrait scaling analyses supported the dimensionality of four functional support scales (emotional–informational, tangible, affectionate, and positive social interaction) and the functional social support index. The MOS is scored on a 5-point Likert scale that asks how often the types of functional support are available; responses range from 1 (not at all) to 5 (all the time). An example of an item indicative of emotional–informational support would be, “someone to give you information to help you understand a situation.” Cronbach’s α coefficients are reported to be >.91 and are fairly stable over time.

The Short Form–36 Health Survey, version 2 (SF–36; Ware, Snow, Kosinski, & Gandek, 1993) is a multipurpose, short-form generic health survey that yields scores in health and well-being in eight areas encompassing physical health (physical functioning, role physical, bodily pain, and general health) and emotional health (vitality, social functioning, role emotional, and mental health). It is a generic measure, as opposed to one that targets a specific age, disease, or treatment group. It has been extensively used in social science and health-related research with reliability and validity widely reported in the literature (Ware et al., 1993).
The Beck Depression Inventory–II (BDI–II; Beck & Steer, 1987) is a 21-item self-report instrument that reflects both the cognitive–affective and somatic aspects of depression. It is a reliable and well-validated measure of depressive symptoms. Cronbach’s α coefficients for the BDI–II range from .73 to .95. Scores range from 0 to 63; higher scores indicate greater depression.

The Beck Anxiety Inventory (BAI; Beck & Steer, 1990) is a 21-item self-report instrument that measures anxiety symptoms in adolescents and adults. It is a reliable and well-validated measure of symptoms of anxiety. Beck, Epstein, Brown, and Steer (1988) reported that the BAI had high internal consistency reliability (Cronbach’s α coefficient = .94). Scores range from 0 to 63; higher scores indicate greater anxiety.

**Procedures**

Participants were identified and recruited through occupational therapists who referred them for the study. We contacted the participants by phone to explain the study, the goals, and the inclusion and exclusion criteria. Potential participants were given the opportunity to decline participation in the study without disclosing personal information. People meeting the criteria and interested in participating in the study were then scheduled for a testing session. Consent forms were signed before testing, and participants were reminded that they could withdraw from the study at any time.

The ASQ screening and the ADULT–SI interview were given in a 2-hr session, and the participants also completed the questionnaires, which included the AASP, the SF–36, the MOS Social Supports Survey, the BDI–II, and the BAI. After identifying 14 SOR participants on the basis of the ASQ (a score ≥10), additional participants were recruited as an NSOR control group matched as closely as possible for age and gender.

**Data Collection and Analysis**

Data were collected in a face-to-face session with each participant. Time was allotted for the completion of the five paper-and-pencil self-report questionnaires, and questions were clarified on request. The questionnaires included the AASP, MOS, SF–36, BAI, and BDI–II. The questionnaires were scored, and raw scores were entered into an SPSS Version 16 (SPSS, Inc., Chicago) database. Analyses included an analysis of variance to determine differences between SOR and NSOR groups, correlation matrix to explore the relationships among variables, factor analysis to explore grouping of variables and, finally, a correlation between the eight indicators of HRQOL and the four sensory quadrants of the AASP.

**Results**

Twenty-eight adult volunteers ages 18 to 60 participated in the study. The SOR group consisted of 14 adult volunteers referred by an occupational therapist and identified as SOR by an ASQ score ≥10. After the identification of the SOR group, a matched comparison group of 14 NSOR adults was recruited (ASQ scores <10), matched to the SOR group by age and gender. No significant differences between SOR and NSOR groups were found in gender (SOR group: 3 men, 11 women; NSOR group: 4 men, 10 women) or age (SOR group: mean [M] = 40.38, standard deviation [SD] = 11.55; NSOR group: M = 40.00, SD = 11.00).

Participants were tested on the AASP as well as the ASQ to determine their sensory response style; reliability between the two measures was .83 (p = .001). A t-test calculated between the SOR and the NSOR groups on these measures indicated that a significant difference (p = .0001) was found between the two groups on both measures. The two groups appear to process sensory input differently; the SOR group processed information in a way characteristic of a low threshold, or overresponsiveness (Dunn, 2001).

The first research question addressed the baseline differences between the SOR group (n = 14) and the NSOR group (n = 14). A one-way analysis of variance was performed with group membership as the independent variable and mental health and quality-of-life indicators as the dependent variables. Table 1 depicts the differences between the groups (p = .05) on depression;

<table>
<thead>
<tr>
<th>Measure</th>
<th>SOR Group</th>
<th>NSOR Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOS</td>
<td>68.64</td>
<td>81.07</td>
</tr>
<tr>
<td>BDI–II</td>
<td>11.00</td>
<td>11.95</td>
</tr>
<tr>
<td>BAI</td>
<td>14.29</td>
<td>10.33</td>
</tr>
<tr>
<td>SF–36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical Functioning</td>
<td>28.00</td>
<td>29.14</td>
</tr>
<tr>
<td>Role Physical</td>
<td>17.14</td>
<td>17.89</td>
</tr>
<tr>
<td>Bodily Pain</td>
<td>9.07</td>
<td>11.04</td>
</tr>
<tr>
<td>General Health</td>
<td>18.81</td>
<td>21.80</td>
</tr>
<tr>
<td>Vitality</td>
<td>12.36</td>
<td>15.21</td>
</tr>
<tr>
<td>Social Functioning</td>
<td>8.00</td>
<td>9.64</td>
</tr>
<tr>
<td>Role Emotional</td>
<td>12.14</td>
<td>14.36</td>
</tr>
<tr>
<td>Mental Health</td>
<td>18.14</td>
<td>21.21</td>
</tr>
</tbody>
</table>

Note. BAI = Beck Anxiety Inventory; BDI–II = Beck Depression Inventory–II; M = mean; MOS = Medical Outcomes Social Support Survey; ns = not significant; SD = standard deviation; SOR = sensory overresponsive; NSOR = non–sensory overresponsive; SF–36 Short Form–36 Health Survey.

*p < .05. **p < .01
Research Question 2 examined the relationships among SOR and symptoms of anxiety and depression, social supports, and HRQOL for the total sample (N = 28). As can be seen in Table 2, a strong, significant relationship existed between SOR and anxiety (BAI; \( r = .66 \), \( p = .001 \)) and between anxiety and depression (BAI and BDI–II; \( r = .70 \), \( p = .001 \)) in contrast to a low and significant (\( r = .37 \), \( p = .001 \)) relationship between SOR and depression (BDI–II). A moderate, significant, inverse relationship (\( r = -.53 \), \( p = .001 \)) was found between MOS scores of perceived social support and anxiety, indicating that less perceived social support was related to increased anxiety. A moderate (\( rs = .40–.49 \)) significant positive relationship was found between MOS scores and the HRQOL indicators of vitality, social function, role emotional (participation), and mental health in HRQOL, indicating that increased perceived social supports were related to increased scores in these HRQOL indicators.

To further explore the relationships among the 13 variables (MOS; BDI–II; BAI; ASQ; score defensive; and HRQOL scores of physical function, role physical, bodily pain, general health, vitality social function, role emotional, and mental health), the scores were submitted to an exploratory factor analysis using squared multiple correlations as prior communality estimates. The principal factor method was used to extract the factors, followed by a promax (oblique) rotation to simple structure. A scree test and mineigen >1 criteria suggested either two- or three-factor solutions; however, with only two variables loading on the third factor, only two factors were retained, which explained 79% of the total variance. The interfactor correlation was −.47, and the reference structure matrix (see Table 3) was used to interpret the factors. The coefficients represent semipartial correlations between variables and common factors after removing from each common factor the effect of the other common factor. To facilitate inspection of the structure, variables were flagged as loading on the factor when the coefficient was ≥.40 for one factor and <.40 for the other. The 13 variables show clear simple structure with high factor loadings on only one factor and near-zero loadings on the other. It appears that the following variables are measures of a common construct (factor) named “sensory–social–emotional”: MOS, BDI–II, BAI, ASQ, score defensive, social function, role emotional, and mental health. The
remaining variables (physical function, role physical, bodily pain, general health, and vitality) appear to be measures of a common construct named “physical–health–vitality.”

To answer Question 3 on the relationship between the eight HRQOL indicators and sensory processing styles as measured by the AASP, a correlation was calculated among the eight HRQOL indicators and the four sensory quadrants of the AASP. Significant relationships between sensory processing quadrants and HRQOL are presented in Table 4. Three of the four quadrants (sensory sensitivity, sensory avoiding, and low registration) were correlated (p = .05) with HRQOL factors of role emotional and mental health. Both sensory avoiding and low registration were correlated (p = .05) with decreased social functioning and vitality. Sensory avoiding uniquely affected six of the eight HRQOL indicators (p = .05), including decreased role emotional (participation), mental health, social functioning, general health, and increased bodily pain. Sensory sensitivity was related to two HRQOL indicators: role emotional (p = .028) and mental health (p = .048). By contrast, sensory seeking was correlated with increased vitality, which was the one sensory processing style that correlated with a positive indicator of HRQOL.

Discussion

The results of the study identified a significant difference between adults with SOR and those without SOR in sensory scores as well as anxiety and depression scores. SOR was found to be significantly correlated with anxiety (r = .66, p = .001) and was inversely correlated with social supports (r = −.53, p = .05), suggesting that increased symptoms of anxiety are related to fewer perceived social supports. Increased symptoms of depression were also related to decreased perceived social supports. These results support findings of a relationship between SOR and social–emotional factors, including increased symptoms of anxiety, as described in previously cited research (Kinnealey & Fuiek, 1999; Pfeiffer et al., 2005), and clarify a more specific role for perceived social supports as a possible mitigating factor.

The factor analysis identified two factors, (1) Sensory–Social–Emotional and (2) Physical–Health–Vitality, that suggest a sensory-based difference between the two groups in life perception and experiences. The sample did not include people with diagnosed conditions, so test scores indicate tendencies and perception, not illness or pathology. People with SOR may be at higher risk for mental health symptoms. It must not be construed, however, that this apparent clinical relationship is inevitable. A lifestyle that promotes sensory self-regulation and compatibility with the sensory environment, as well as mitigating factors such as social support and occupational choice, can provide a foundation for quality of life.

The findings expand the understanding of the relationships between SOR and HRQOL indicators, including decreased vitality (r = −.37, p = .009), poorer social functioning (r = −.40, p = .042), decreased general health (r = −.43, p = .017), and increased bodily pain (r = .36, p = .012). In addition, the SF–36 has eight subscores, two of which (role emotional and role physical) depict participation in social roles, including daily occupations. A moderate and significant inverse correlation was found between SOR scores and role emotional (r = −.42, p = .05), reflecting that as SOR scores increased, the role emotional (participation) scores decreased. A moderate and significant inverse relationship was found between SOR scores and mental health (described as feelings of nervousness vs. calm; r = −.44, p = .01) and between SOR scores and social functioning (described as performing social activities without interference because of physical or emotional problems; r = −.40, p = .05). This finding suggests that as SOR increases, mental health and social functioning decrease.

Results of the SF–36 indicated no significant difference in HRQOL between the SOR group and the NSOR group in the areas of physical functioning, role physical, role emotional, and mental health. However, a significant difference was found between groups in HRQOL on bodily pain, general health, vitality, and social functioning.

### Table 4. Significant Correlations Between Sensory Processing and Health-Related Quality of Life (Short Form–36)

<table>
<thead>
<tr>
<th>Sensory Sensitivity</th>
<th>Sensory Avoiding</th>
<th>Low Registration</th>
<th>Sensory Seeking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decreased:</td>
<td>Decreased:</td>
<td>Decreased:</td>
<td>Increased:</td>
</tr>
<tr>
<td>Role Emotional (p = .028)</td>
<td>Role Emotional (p = .038)</td>
<td>Role Emotional (p = .004)</td>
<td>Vitality (p = .025)</td>
</tr>
<tr>
<td>Mental Health (p = .048)</td>
<td>Mental Health (p = .11)</td>
<td>Mental Health (p = .002)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Social Function (p = .028)</td>
<td>Social Function (p = .016)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vitality (p = .036)</td>
<td>Vitality (p = .001)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>General Health (p = .014)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increased:</td>
<td>Increased:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bodily Pain (p = .045)</td>
<td></td>
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</tbody>
</table>

The American Journal of Occupational Therapy

325
The MOS assesses a person’s perception of his or her perceived social support. No significant difference between the SOR and NSOR groups was found on this measure. There was, however, a moderate, significant relationship \((r = .49, p = .001)\) between MOS scores and role emotional (participation) for the total group. This finding suggests that as perceived social supports increased, participation in social roles increased. In fact, perceived social support may be an important mitigating factor for the person with SOR by positively affecting participation in social role \((r = .41, p = .05)\), vitality \((r = .43, p = .05)\), and mental health \((r = .40, p = .05)\). This finding has implications for intervention and indicates that effective intervention should include interventions that develop and maintain social support networks that can be maintained by the person with SOR.

The relationship between HRQOL indicators and the sensory response quadrants on the AASP demonstrated clear differences among quadrants. Sensory sensitivity, sensory avoiding, and low registration all showed a significant, negative relationship with HRQOL in the areas of role emotional and mental health. Sensory avoiding was significantly related to 6 of the 8 HRQOL indicators and was uniquely related to decreased general health and increased bodily pain; it may be considered a risk factor related to HRQOL. Low registration was correlated with 4 of 8 HRQOL indicators, including poorer social functioning and vitality, indicating a potential risk factor. Sensory sensitivity was significantly related to role emotional and mental health and appears to be less of a risk factor than sensory avoiding. By contrast, sensory seeking was positively correlated with vitality, suggesting that high scores in sensory seeking may be a protective factor. This finding supports the research of Jerome and Liss (2005), suggesting that sensory seeking be considered a protective factor. These patterns should be viewed as preliminary and informative—not diagnostic—because a wide range of normal processing and behavior differences among the four sensory response quadrants were noted. Our study requires replication.

The findings of this study are helpful in expanding insight into the differential relationships between sensory response patterns and affective mental health symptoms, functional health, and ability to participate in social roles. This area of investigation could provide therapists with information for anticipatory guidance to improve HRQOL when working with clients with sensory styles that are incompatible with daily activity patterns. People who fall into the category of SOR—especially sensory avoiding—may be the most at risk for HRQOL issues. Interventions in younger populations traditionally address sensory regulation or imbalance using the sensory integration approach and establishing daily and weekly patterns of sensory, motor, and social activities. Effective intervention should also include enabling and empowering a person through insight into his or her sensory makeup and guidance in developing and maintaining social supports.

Limitations of this exploratory study include small sample size, single site, and narrow demographic representation. Future research should replicate and improve the procedures, expand the sample size, and extend the study to other populations that exhibit sensory processing and modulation characteristics. Other studies should evaluate the results of intervention to provide evidence for the effectiveness of intervention with a variety of populations. Finally, strengthening QOL indicators and improvement of social supports may be measures of successful intervention. ▲

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