Assessing the Restorative Quality of Healthcare Indoor Environment

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Abstract. The restorative quality of healthcare environment is of vital significance for patients’ mental well-being, which would influence their overall recovery through an psychology-physiology interaction. However, there were few applicable methods to assess such quality. This study was therefore conducted to develop the Hospital Indoor Restoration Scale (HIRS) for the user-centered environmental evaluation. To achieve this, a literature review was made to screen out items of the scale, which was tested with surveys among patients, and further modified through statistical analyses. The result shows that the restorative quality of hospitals’ indoor environment could be evaluated by the 16-item scale of three dimensions, namely Vitality, Reassurance, and Support. The model could explain 73.61% of the variance, and the Confirmatory Data Analysis shows that it fits the hypothesis well and has good validity ($\chi^2/df=3.20$, GFI=0.91, CFI=0.95); The Cronbach $\alpha \geq0.88$, indicating good reliability of the scale. The study has completed the theoretical construction of hospitals’ indoor restoration and offered a guidance for related architects, managers and policy makers to make evaluations and optimization of healthcare environment for patients’ restorative outcome improvement.

1. Introduction
Hospitals are often thought of as horrifying and annoying places, which are crowded, noisy and even filled with a sense of death. Doctor-patient disputes are always happening and patients’ negative emotions in medical care become common problems. With the development of Holistic Medicine in the second half of the 20th century, it has been cognized that there are connections between people’s psychological and physical health. Patients’ mental well-being may greatly influence their recovery of body functions and in turn the overall healing process [1]. Healthcare indoor environment, where patients stay during most of their medical processes, could greatly affect their mental states through an environment-psychology interaction [2]. Therefore, the restorative quality of hospitals’ environment is essential for patients’ recovery.

When it comes to environmental impacts on people’s mental health, the theories of restorative environments are of vital significance, which have pointed out mental stress and mental fatigue as two major obstacles of mental well-being. According to Ulrich’s Stress Reduction Theory (SRT) [3], threatening or challenging situations would cause people’s psychological stress, which is usually accompanied by emotion changes, such as the rise of anger and fear. While the process would inverse if the environment is replaced by the one which is more steady, natural and fascinating. While in Kaplan’s Attention Restoration Theory (ART) [4], people tend to perform directed attention when dealing with tough mental work, in order to maintain its accuracy and efficiency. During the process, attention resources would be consumed, giving rise to mental fatigue, which manifests itself in the loss
of emotion control and physical breakdown. While the attention resources could get restored with the assistance of restorative environment, which also requires little resource consumption.

Patients in hospitals usually experience both psychological consumption and restoration. Firstly, negative emotions such as stress, fear, anxiety are always caused by illness and doctor-patient conflicts. Besides, attention resources could be greatly assumed by complicated medical procedures. Therefore, there is necessity to improve the restorative quality of healthcare environment to block the consumption procedure and promote the restoration one. That way, it is important to make evaluations of hospitals’ environment restoration and find out ways to guide future designs.

Currently, several restorative environment scales were developed, while most of them were based on ART, targeting mainly on the environment restorative quality of mental fatigue [5-7]. In Han’s research, the Short-version Revised Restoration Scale (SRRS) was developed with the combination of SRT and ART [8]. However, the development of SRRS was based on outdoor landscapes, and some of its items had major bias when evaluating healthcare environments.

Therefore, this study was carried out to develop the Hospital Indoor Restoration Scale (HIRS), which would not only provide hospital architects, managers and policy makers with important dimensions to optimize the hospitals’ restorative quality, but also serve as an objective tool to assess and improve the restorative outcomes. Therefore the restorative experience of patients would have more opportunities to get enhanced, which could help them recover better from mental stress and fatigue, and in turn speed up the rehabilitation process.

2. Methodology

2.1 Scene Slides Selection

The images used as scene slides were collected based on the classification of hospitals’ indoor spaces [9], including patient wards, waiting spaces, diagnostic/treatment units, and circulation spaces. Three stages were conducted to pick out appropriate images, which could ensure accurate feedback and distinction of restorative perceptions. First, nearly 300 horizontal images were selected from thousands of color pictures showing the four types of healthcare spaces. Second, 96 slides were picked out based on three criteria: good photographic clarity, shot at eye level, no distortion of shapes or colors. Thirdly, the slides were evaluated in terms of three basic environment features, namely complexity, tone, and openness [10,11], to form a set of slides with different levels of visual senses. Finally, 32 scene slides got screened out with 8 pictures for each space type, consisted of the combination of 2×2×2 levels (high or low, warm or cool) of the three features. Figure 1 has displayed some of the slides selected.

![Sample slides of the four hospital space types.](image)

2.2 Development of Restoration Scale

The development of the HIRS was based on the theories of Medicopsychology, Environmental restoration, and Environmental psychology, through the analyses of which 25 test items plus 1 opposite item were developed, written in short sentences to describe the related feelings in the environment, and were accompanied by a seven-point Likert scale, as shown in table 1.
Table 1. Hospital Indoor Restoration Scale (with 25 items).

Imagine you were located in the presented environment, how would you agree with the following statement? Rate each item with 1-7 according to your degree of agreement. 1-completely disagree, 7-completely agree.

| No. | Items                                                                 | No. | Items                                                                 |
|-----|----------------------------------------------------------------------|-----|----------------------------------------------------------------------|
| v1  | My anxiety relieves in this environment.                            | v14 | I feel immersed in the environment.                                  |
| v2  | My fear relieves in this environment.                               | v15 | I am free here.                                                      |
| v3  | My anger relieves in this environment.                              | v16 | I could do the things I want here.                                  |
| v4  | My depression relieves in this environment.                         | v17 | This is what hospital environment should be like.                    |
| v5  | My loneliness relieves in this environment.                        | v18 | I feel a sense of belonging here.                                   |
| v6  | I can get rid of my everyday routine.                               | v19 | I feel familiar to this environment.                                |
| v7  | I tend to forget my illness here.                                   | v20 | I feel safe in this space.                                          |
| v8  | This environment is new and refreshing.                             | v21 | I could obtain dignity here.                                        |
| v9  | There are many fascinating points in the space.                     | v22 | I can talk freely here.                                              |
| v10 | The environment is full of vitality.                                | v23 | My privacy is protected here.                                       |
| v11 | I don't mind staying here a little longer.                           | v24 | I feel comfortable here.                                            |
| v12 | This environment is rich in content.                                | v25 | I could control this environment.                                   |
| v13 | The environment evokes many of my memories or thoughts.            | v26 | This environment is monotonous in content. (opposite to item v12)    |

According to SRT, the restorative feature of an environment could be reflected through a measurement of space users’ emotion change, also regarded as the affective restoration [12,13]. As for patients in hospitals, the major emotional features contain different levels of anxiety, fear, anger, depression, and loneliness [14], which served as the basis of item v1—v5. Restorative procedure is a dynamic rather than static state. Therefore, the questions were developed to ask about the relief degree of each emotion, which was a difference from former restorative scales. Another dimension of environmental restoration is people’s attention restoration [15,16]. According to ART, there are four features of environments’ restorative quality, including Being-away, Fascination, Extent, and Compatibility, based on which item v6—v17 were developed. Besides, personal perceptions of the environment could also be influential, which mainly include the feelings of safety, privacy, comfort, belonging, familiarity, dignity, social support, and environmental control [17,18], and item v18—v25 were developed accordingly. Item v26 was created as a screening principle in opposite to item v12.

2.3 Scale Testing

The scale testing was carried out in two steps. First, the initial scale was tested among 188 patients, who were recruited via existing patient communication groups. The participants were asked to view the scene slides and imagine that they were staying in the environments displayed, after which they were asked to score the items of the scale. To avoid practice effects, a participant was supposed to evaluate only one picture at a time. A total of 188 copies of scale were sent out and 176 copies were collected, including 154 valid copies responded, with the valid response rate of 87.5%. A response would be invalid if it satisfy one of the following conditions: (1) The number of missing answers are more than 2; (2) There is a consistent tendency of the answers; (3) There exists regularity of the answers; (4) There is consistency between opposite questions. The valid samples were from 74 males and 80 females, whose ages ranged from 22 to 67 years old, with an average age of (42±10) years.
Second, the formal test was conducted with the formal scale. The formal scale was developed based on the final version of the initial scale, which was further modified with Item Analysis and Exploratory Data Analysis. SRRS was also included as the criterion to test the scale’s Criterion-Related Validity, which is a readily available tool to measure environmental restoration, with 8 items covering four dimensions, namely emotion, physiology, cognition, and behavior. SRRS adopts a nine-point Likert scale, and has good reliability and validity.

The formal test was carried out among 463 patients, with 455 copies collected, among which 403 were valid, the valid response rate being 88.6%. The screening principle was the same as that of the initial test. The effective samples included 194 male and 209 female patients aged 12-65 years old with an average age of (37±17) years.

In the study, SPSS 24.0 was used for Item Analysis, Exploratory Data Analysis, Criterion-Related Validity test and Reliability Analysis of the collected data, and Amos 24.0 was used for Confirmatory Factor Analysis. The initial test sample (n=154) was used for Item Analysis and Exploratory Data Analysis, and the formal test sample (n=403) was used for Confirmatory Data Analysis, Criterion-Related Validity test and Reliability test.

3. Results and Discussions

3.1 Item Analysis

Firstly, The correlation coefficient between the score of each item and the total score was calculated to learn about the internal consistency of the scale. The result showed that the coefficient for item v7 was under 0.5 (r<0.5), which meant it was not a proper item to include in the scale, and thus got excluded. While the coefficients for the other 24 items ranged from 0.603 to 0.848 (r>0.5), and in turn got included. All of the calculations satisfied $P<0.001$.

Secondly, the total score of each questionnaire was calculated and ranked from high to low. The scores of each item from the top 27% group and bottom 27% group were tested by the Independent-Sample Test, which showed statistical significant differences ($P<0.001$) of all the 24 items between the two groups. The result indicated good discriminate validity of the scale with these items.

3.2 Exploratory Data Analysis

The Exploratory Data Analysis was carried out to explore the principal components of the scale and further screen the items, making the scale more efficient and clarified in structure [19].

The result of Bartlett's Sphericity Test showed that the KMO value was 0.926 and Bartlett $\chi^2=3427.09$ (P<0.001), which indicated the appropriateness for principal component analysis. The items with factor loads less than 0.60 or more than 0.5 in 2 dimensions were excluded from the scale. After twice exploratory factor analyses, a total of 16 items were retained, forming a Component Matrix of 3 dimensions, which explained 73.61% of the variance, with the extraction of 0.58–0.85, and the factor loading of 0.61–0.83. Table 2 displays the scale’s Rotated Component Matrix. The division of the principal components has illustrated that there are some deviations from the original dimensions. Therefore, the three dimensions have been renamed according to the character of items in each dimension. The first dimension contains v8, v9, v10, v12 and v13, which describes the dynamic and energetic feature of an environment. Therefore it is named as Vitality, with the total variance of 4.04 and the variance explanation rate of 25.26%. The second dimension contains v1—v5, reflecting the impact an environment has on people’s emotion state, and is thus named as Reassurance, with the total variance of 3.93 and the variance explanation rate of 24.55%. The third dimension contains v16, v19, v20, v22, v23 and v25, indicating the supportive and protective feature of an environment. Thus it is named as Support, with the total variance of 3.81 and the variance explanation rate of 23.80%.

Table 2. Rotated Component Matrix$^a$ of the 16-item scale (n=154)

| Component | 1 (25.26%) | 2 (24.55%) | 3 (23.80%) |
|-----------|------------|------------|------------|
| V12       | 0.808      | V4         | 0.832      |
| V25       | 0.792      |            |            |
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V13 0.806 V2 0.824 V22 0.769
V10 0.798 V3 0.820 V23 0.715
V9 0.780 V1 0.751 V16 0.713
V8 0.740 V5 0.673 V19 0.646

* Rotation converged in 6 iterations.

3.3 Validity Analysis

3.3.1 Confirmatory Data Analysis. The Confirmatory Data Analysis was adopted to test whether the collected data accord with the three-dimension structure concluded after the Exploratory Data Analysis [20]. The result is displayed in figure 2, showing that all the Squared Multiple correlations ($R^2$) of the 16 items are greater than 0.50, indicating good convergent validity of the structure. The pairwise correlation calculation between the three dimensions shows that all of the coefficients are under 0.85, illustrating a good discriminant characteristic of the structure. Other important indexes of model fit have also been calculated, namely $\chi^2 = 323$, $df = 101$, $\chi^2/df = 3.20$, $GFI = 0.91$, $CFI = 0.95$, $NFI = 0.93$, $IFI = 0.95$, $TLI = 0.94$, $RMSEA = 0.07$, which are all within reasonable ranges. All of the above results indicate no severe deviation from the hypothesized model.

Figure 2. Confirmatory model of the formal scale.

3.3.2 Criterion-Related Validity Analysis. The Criterion-Related Validity of the scale was further tested to verify the correctness and efficiency of the dimensions. As for SRRS, there is an increasing trend of environmental restoration with the score growth of the emotion, cognition and behavior dimensions, which is in consistent with that of HIRS’ three dimensions. While for the sake that the dimension of physiology mainly characterise the growth of negative physiological data, there is a descending trend of environmental restoration with the score growth, which is opposite to that of HIRS’ three dimensions. The results of the correlation analysis are in coherence with the hypothesis as shown in table 3. Among the correlation coefficients measured pairwise, only those between Physiology and the dimensions of HIRS are less than 0.50 ($P<0.01$), indicating that the Criterion-Related Validity is in general acceptable. The low coefficients maybe because of the bias caused by the judgement of physiological states only through self-assessment.

Table 3. Correlations between the dimensions of HIRS and SRRS ($r$)

| HIRS       | Emotion | Physiology | Cognition | Behavior |
|------------|---------|------------|-----------|----------|
| Vitality   | 0.53**  | -0.20**    | 0.64**    | 0.57**   |
| Reassurance| 0.56**  | -0.26**    | 0.53**    | 0.48**   |
| Support    | 0.63**  | -0.23**    | 0.66**    | 0.60**   |

**. Correlation is significant at the 0.01 level (2-tailed).
3.4 Reliability Analysis
Reliability describes the degree of consistency and stability of the test results, which assesses whether the evaluation of the scale changes with time or situation. Reliability could be judged through the calculation of the Internal Consistency Reliability, and one of the most well accepted measurements is Cronbach coefficient alpha (Cronbach α). According to the results of the calculation, the Cronbach α of the dimensions of Vitality, Reassurance and Support was 0.91, 0.91, 0.88 respectively, with the overall Cronbach α=0.94, indicating good internal consistency reliability of the scale.

4. Conclusion
In the study, the Hospital Indoor Restoration Scale has been developed for the measurement of the environmental restorative quality of hospitals’ indoor spaces. The reliability and validity have been further analysed, and the results show that the scale is qualified to assess healthcare environment.

Besides, three dimensions to characterise healthcare environments’ restorative quality have been screened out, namely Vitality, Reassurance and Support, which could serve as a guidance for the optimization of healthcare environment to improve patients’ mental health.

Furthermore, the scale has combined multiple theories related to environmental restoration, forming an integrate assessment of patients’ mental well-being, which also helps to build a thorough knowledge system of hospitals’ restorative quality.

References
[1] Ananth S 2008 The natural next step Explore-NY 4 273-4
[2] Tanja-Dijkstra K and Pieterse M E 2011 The psychological effects of the physical healthcare environment on healthcare personnel Cochrane Db. Syst. Rev. 101 6210
[3] Ulrich R S 1983 Aesthetic and Affective Response to Natural Environment Behavior & the Natural Environment 6 85-125
[4] Kaplan R and Kaplan S 1989 The Experience of Nature: a Psychological Perspective (England: Cambridge University Press) p 65-123
[5] Hartig T, Korpela K, Evans G W and Gärling T 1996 Validation of a Measure of Perceived Environmental Restorativeness (Sweden: University of Göteborg) p 3-56
[6] Hartig T, Korpela K, Evans G W and Gärling T 1997 A measure of restorative quality in environments Scandinavian housing and planning research 14 175-94
[7] Laumann K, Gärling T and Stormark K M 2001 Rating scale measures of restorative components of environments J. Environ. Psychol. 21 31-44
[8] Han K T 2003 A reliable and valid self-rating measure of the restorative quality of natural environments Landscape Urban Plan. 64 209-32
[9] Verderber S 2010 Innovations in Hospital Architecture (New York: Routledge) p 45-101
[10] Berlyne D E 1973 Aesthetics and Psychobiology (New York: Appleton-Century-Crofts) p 1-19
[11] Mehrabian A and Russell J A 1974 An Approach to Environmental Psychology (Boston: the MIT Press) p 4-79
[12] Hartig T, Evans G W, Jamner L D, Davis D S and Gärling T 2003 Tracking restoration in natural and urban field settings J. Environ. Psychol. 23 109-23
[13] Ulrich R S 1979 Visual landscapes and psychological well-being Landscape Res. 4 17-23
[14] Schilder P 1953 Medical Psychology (Oxford: International Universities Press) p 20-179
[15] Ottosson J and Grahn P 2005 A comparison of leisure time spent in a garden with leisure time spent indoors: on measures of restoration in residents in geriatric care Landscape Res. 30 23-55
[16] Laumann K, Gärling T and Stormark K M 2003 Selective attention and heart rate responses to natural and urban environments J. Environ. Psychol. 23 125-34
[17] Bell P A, Greene T C, Fisher J D and Baum A 1996 Environmental Psychology (London: Psychology Press) p 96-165
[18] Gifford R 1987 Environmental Psychology: Principles and Practice (Needham Heights: Allyn
& Bacon) p 15-124

[19] Kim J and Mueller C W 1978 *Factor Analysis: Statistical Methods and Practical Issues* (Newbury Park: Sage) p 21-101

[20] Kline R B 2015 *Principles and Practice of Structural Equation Modeling* (New York: Guilford Press) p 12-111