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Do the hospital rooms make a difference for patients' stress? A multilevel analysis of the role of perceived control, positive distraction, and social support

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Introduction

The qualities of the healthcare physical environment have been demonstrated to prevent or to reduce patients' stress and to promote patients' satisfaction and recovery (e.g., Ulrich et al., 2008). However, the application of this evidence to practice is still limited, which means that healthcare providers are missing an opportunity to improve the quality of care (e.g., Stall, 2012).

Perhaps one barrier to more widespread consideration of the design of the physical environment in healthcare settings is the paucity of theory about the role of the physical environment on patients' outcomes. The healthcare field produces many empirical findings and observations but unfortunately these have not contributed to a coherent understanding of the relevant parameters or to the development of more elaborated theories (cf. Lewicka, 2011). One exception is the Theory of Supportive Design (Ulrich, 1991, 2001). This theory emphasizes three properties of healthcare settings that contribute to stress reduction: providing opportunities for environmental control, social support, and positive distraction. However, only recently has this theory been revisited and tested in a laboratory experiment (Andrade & Devlin, 2015). The main aim of the present paper is to test Ulrich's model through a field study, using an approach that is innovative in several ways: a) the use of a refined measurement of the quality of physical environment, including both objective and subjective data, and of multilevel analysis of nested data from hospital rooms; b) the focus on the psychological processes that link the objective qualities of the environment and patients' stress, and c) the exploratory examination of the moderating role of the cultural context.

1.1.The link between the healthcare physical environment and patients' stress

There is ample evidence that the healthcare physical environment plays a role in both objective and subjective indicators of patients' stress. For example, the enhancement of the

environment of waiting areas was associated with improved mood and altered physiological state (Leather, Beale, Santos, Watts, & Lee, 2003) or to lower reported anxiety before and after consultation with a doctor (see also, Rice, Ingram, & Mizan, 2008). Some evidence comes from studies focused on individual features of the environment. For example, it was found that better acoustics were associated with lower pulse amplitude (Hagerman et al., 2005); that, compared to patients with a view of a brick wall, patients with a view to nature received fewer negative evaluative comments in nurses' notes (Ulrich, 1984); and that rooms with plants significantly enhanced physiological responses as evidenced by lower systolic blood pressure; lower ratings of pain, anxiety, and fatigue; and also more positive feelings and higher satisfaction about their hospital room (Park & Mattson, 2009). As another example, a hospital isolation room with concrete walls was redecorated with wood paneling and Japanese paper, and then compared with an unchanged room (Ohta et al., 2008). In the redecorated room patients felt more thermally comfortable and had lower levels of stress, as measured by cortisol secretion.

Experimental studies have used hospitalization scenarios to predict the level of expected stress. Dijkstra, Pieterse, and Pruyn (2008b) found that a photo of a hospital room with indoor plants resulted in less perceived stress than did a room with a painting of an urban environment on the wall. The same authors investigated the effect of the color of the environment and showed that, compared to white, the color orange had an impact on feelings of arousal and that the color green tended to have stress-reducing effects (Dijkstra, Pieterse, & Pruyn, 2008a).

These studies provide cumulative evidence that the healthcare physical environment contributes to patients' stress and associated affective and physiological reactions. However, more research is required to move research and theory forward. Overall, these studies focus on a single feature of the physical environment or on an indistinct set of characteristics, lack

sufficient variability of environmental sampling, and pay attention to predictors and not to the possible psychological mechanisms through which the environment affects stress (see also Winkel, Saegert, & Evans, 2009). These challenges will be discussed in the next section.

1.2.The measurement of the healthcare physical environment contextual variables and the separation of its impact on patients' outcomes

The objective qualities of the physical environment of healthcare facilities are not easy to operationalize and to measure. The number of hospital physical features that may affect patients is virtually unlimited, and features may co-occur (e.g., room size and occupancy). This situation makes it difficult to isolate the effect of a single feature, and to rule out confounding variables. Moreover, in the absence of theory, the choice of variables to study either must be very selective (e.g., the view) or use categories that are very broad (e.g., "physical factors") (see also Lewicka, 2011).

Studies examining the influence of objective qualities of the hospital environment on patients' outcomes have focused on one specific feature, or have assessed those qualities by a) comparing environments pre- and post-relocation or renovation (e.g., Leather et al., 2003; Rice et al., 2008), b) comparing environments with different levels of attractiveness or modernity (e.g., LaVela, Etingen, Hill, & Miskevics, 2016), and/or c) using experts' evaluations of environmental quality (e.g., Fornara, Bonaiuto, & Bonnes, 2006). Much of the current field research in healthcare basically relies on users' perceptions, with objective qualities or assessments used only to separate the samples of renovated-unrenovated, attractive-unattractive, or high-low quality settings. One of the limitations of relying only or mostly on subjective evaluations to predict patients' outcomes is that perceptions of the physical environment can be affected by other factors such as the perceptions of the quality of staff and care (Andrade, Lima, Devlin, & Hernandez, 2016).

Since most of the healthcare studies have neglected the unique and independent role of the objectively measured physical environment (Winkel et al., 2009), it is still legitimate to question whether and to what extent the actual physical features of the hospital predict patients' outcomes. An experimental laboratory study sought to disentangle the unique effect of the hospital physical environment on patients' expected outcomes (Andrade et al., 2016). This study confirmed that the quality of the physical environment (manipulated by presenting photographs of an inadequate, neutral, or good quality hospital setting) makes a significant and independent contribution to expected subjective well-being over and above the quality of the healthcare social environment (manipulated through a story about a positive, neutral, or negative healthcare experience).

In field studies, it is harder to disentangle the contribution of the objective and subjective qualities of the physical environment. Some have used measures of objective quality along with the perceived quality indicators as predictors of patients' outcomes (e.g., Andrade, Lima, Pereira, Fornara, & Bonaiuto, 2013; Fornara, 2005). By controlling for the level of the environment's objective quality, these studies have suggested that it did not affect patients' outcomes directly, but rather through environmental perceptions. However, this research is limited and has drawbacks. To separate the unique effect of the healthcare physical environment as explanatory of patients' outcomes, researchers not only need enough variability in environmental characteristics but also to acknowledge that the objective qualities of the physical environment belong to a superordinate level of analysis. Andrade et al. (2013) assessed eight, and Fornara (2005) assessed four healthcare settings, and both ignored the hierarchical data structure. By using ordinary regression analysis, these studies treated the characteristics of the settings as if they were individual perceived characteristics, inflating the size of the sample at the level of the environment.

The present research attempts to bridge the above discussed theoretical and methodological gaps by using a refined and systematic assessment of numerous features that vary in hospital settings, and by using a multilevel approach to analyze the separate roles played by the objective physical environment and by individuals' perceptions of that physical environment on stress.

1.3.Chasing theoretical explanations for the impact of healthcare physical environment variables

Literature on healthcare environments has also paid little attention to the underlying psychological processes through which the relationships between the physical environment and patients' outcomes occur, but some exceptions can be found. Andrade et al. (2013) found that in healthcare settings with higher quality in terms of physical conditions, patients were more satisfied because their perceptions of the physical (e.g., spatial-physical comfort, orientation, quietness, views, and lighting) and social (e.g., social and organizational relationships and privacy) environments of the care unit were more positive. Focusing on the specific role of natural elements in the hospital room, Dijkstra et al. (2008b) showed that the stress-reducing effects of indoor plants occur because the environment is perceived as being more attractive. These studies suggest that higher perceptions of quality and attractiveness of the healthcare setting are some of the explanations for the link between the physical environment and patients' well-being.

1.4.Ulrich's theory of supportive design

Ulrich's model proposes that healthcare environments reduce stress if they foster: a) sense of control over physical-social surroundings, b) access to social support, and c) access to positive distractions. Environmental control is defined as the degree to which people

perceive they have "control over various characteristics of their environment" (Lee & Brand, 2005, p. 326). According to Ulrich (2001), design approaches for promoting feelings of control include: bedside dimmers to control lighting, or television that is controllable by individual patients. Social support refers to the psychological and material support received from others that benefit the ability to cope with stress (Cohen, 2004; Haslam et al., 2005). According to Ulrich (2001), the design can enhance conditions to accommodate the presence of family and friends by providing features such as telephones, and convenient overnight accommodations. Positive distractions refer to environmental features that produce "positive feelings, effortlessly hold attention and interest, and therefore may block or reduce worrisome thoughts" (Ulrich, 1992, p. 24, in Devlin & Arneill, 2003). The most effective of these distractions, with a capacity to improve mood and promote restoration from stress, is nature (e.g., Raanaas, Patil, & Hartig, 2012; Salonen et al., 2013). Examples of other design approaches include music, an aquarium, or artwork (Ulrich, 2001).

The theory of supportive design was recently tested through cross-cultural laboratory research (Andrade & Devlin, 2015). Participants were exposed to a hypothetical hospitalization scenario, and results showed that elements and amenities provided by the hospital room reduced expected stress, which was explained (mediated) by perceptions of how much social support and positive distraction the room would promote, but not by perceptions of perceived control.

2. Objectives

The aim of this study is to test Ulrich's theory of supportive design in the field, using both objective and subjective qualities of hospital design features. In particular, the study investigates the impact of objective hospital room features on patients' stress, as mediated by patients' perceptions of the room's qualities in terms of promoting environmental control,

social support, and positive distraction. Our aim is also to identify the effect of the rooms' features on patients' stress, disentangled from patients' perceptions of the hospital room. To do that, the hospital rooms where patients receive care were considered as the contextual unit of analysis, and the amenities those rooms provide were measured as the rooms' objective characteristics, while patients' stress and their perceptions of room qualities were the individuals' level of analysis.

This study is part of a broader cross-cultural research program involving the United States (US) and Portugal, funded by the Academy of Architecture for Health Foundation (blinded for review, 2014). In this project, a major focus was to identify differences by culture reflecting the psychological processes that intervene between the physical environment and the person. The sociocultural context in which the hospital physical environment is embedded may change how its physical features affect people (Winkel et al., 2009), for example by setting different levels of expectations about care, or by relating to cultural values. However, cultural differences have been neglected in research on healthcare environments, limiting our knowledge of whether people from different sociocultural contexts share patterns of responses to healthcare environments (one exception is a study by Devlin, Nasar, & Cubukcu, 2014). To the best of our knowledge, there is not a theory sufficiently developed that could help us create specific hypotheses about cultural differences in the context of healthcare environments. Nevertheless, cultural differences will be explored. The present study will explore sociocultural context as a possible moderator of the routes through which the objective features of the rooms affect individuals' stress.

In sum, this study will test the hypotheses that (1) hospital rooms have an impact on levels of stress and the number of desirable elements in the rooms explain that impact; (2) perceived control, social support, and positive distraction are (some of) the psychological processes linking the number of favorable elements in the room and patients' stress; and (3)

that this mediation is moderated by country (i.e., the mediating processes may occur in different ways in different cultures).

3. Method

3.1.Settings

Data were collected in hospital rooms from five units that housed orthopedic patients and in which the primary surgeries were for hip and knee replacements. Two units were in one private, not-for-profit, acute care general hospital in the US, with 252 beds: one un-renovated (US1) and one renovated (US2) units on the same floor of the hospital. In Portugal data were collected in three units, each in a different hospital in Lisbon: an older public hospital (PT1), an older private hospital (PT2); and a modern private hospital (PT3). From the available rooms in each unit, data were collected in, respectively, 17 (US1), 20 (US2), 11 (PT1), 18 (PT2), and 41 (PT3) different rooms. In the US, all the rooms were single, while in Portugal there were single, double, and a 3-bed rooms.

3.2.Participants

Two hundred and thirty-six people participated in this study. All were orthopedic patients, 78 (33.1%) from the US, and 158 (66.9%) from Portugal. For the purpose of the study and to use the room as the unit of analysis (see Analytic strategy, below), we have only included those patients who stayed in rooms where at least another patient in the study had stayed. Accordingly, 187 patients allocated in 57 rooms compose the sample of this study, 61 (32.6%) from the US, and 126 (67.4%) from Portugal.

In the US, 11 (18.0%) participants stayed on the US1 unit, and 50 (82.0%) stayed in the US2 unit. Fifty-one (83.6%) had been hospitalized in the same hospital before (an

average of 2.71 times). The age of the US subjects ranged from 34 to 86 years with a mean age of 65.85 years (*SD* = 10.08 years). Thirty-five (57.4%) of the participants were women. Most of participants had a college degree or some college (*n* = 33, 54.1%), 2 (3.3%) had less than a high school diploma, 11 (18.0%) had a high school diploma, and 11 (18.0%) had an advanced degree (MA, PhD, or MD).

In Portugal, the participants were patients in PT1 (*n* = 31, 24.6%), PT2 (*n* = 52, 41.3%), or PT3 (*n* = 43, 34.1%), and less than half (*n* = 57, 45.2%) had been hospitalized before in that hospital (an average of 1.86 times). In PT1, 14 participants were in a private room, 11 were in a double room, and 6 were in a 3-bed room. In PT2, 21 participants were in a private room, 22 were in a double room, and 9 were in a 3-bed room. In PT3, 8 participants were in a private room, and 35 were in a double room. The age of the Portuguese patients ranged from 23 to 87 years (*M* = 56.61, *SD* = 16.98 years). Eighty-three (65.9%) of the participants were women, and the majority had less than a high school diploma (*n* = 66, 52.4%). Nineteen (15.1%) had a high school diploma, 25 (19.9%) had a college degree or some college, and only 6 (4.8%) had an advanced degree (MA, PhD, or MD).

3.3.Procedure

At each of the hospitals, appropriate permissions were obtained. In the US, this involved IRB review at both the researcher's home institution and the hospital. In Portugal, the study was approved by the members of the hospitals' administration and the directors of the orthopedic care units, to whom the purpose and method of the study was described in detail.

Patients in the US1 unit participated between mid-December, 2012 and mid-February, 2013, and patients in the US2 participated between early June, 2013 and the end of July, 2013. In Portugal, data were collected between early October, 2013 and mid-January, 2014.

The questionnaires were delivered to patients at least 24 hours after surgery. Both in the US and Portugal, the lead researcher and a research assistant were involved in collecting data. Participants were asked to fill out a questionnaire for a study about patients' perceptions of their hospital rooms. If patients agreed to participate, an informed consent was signed and patients were asked whether they wanted to complete the questionnaire on their own or have the questions read by the researchers. Some patients preferred to be interviewed, given the difficulty of writing following surgery, the degree of fatigue, or insufficient literacy levels (Portugal). Most patients felt well enough to answer questions when approached by the researchers; in relatively few instances, the researchers needed to return (either because patients had visitors or were feeling unwell). At the end, patients received a written detailed description of the research.

3.4.Instruments

3.4.1. *Individual-level variables*

At the individual-level, we measured the mediating (perceived control, social support, and positive distraction) and the dependent (self-reported stress) variables.

To measure the perceived level of control over the physical environment we used five items ($\alpha = .83$) (e.g., "I can control the physical features of my hospital room"), positive distraction provided by the physical environment was measured through four items ($\alpha = .80$) (e.g., "In this room my attention is drawn to interesting things"), and to measure the perceived social support provided by physical environment six items were used (e.g., "This hospital room provides good opportunities for engaging in social activities) ($\alpha = .89$). These items compose the Supportive Hospital Environment Design Scale (SHEDS) developed by Andrade and Devlin (2015). All were answered on a Likert scale from 1 (strongly disagree) to 5 (strongly agree), and the factor validity was inspected through a confirmatory factor

analysis (CFA) (Bollen, 1989). We specified a model with three conceptual latent variables that were allowed to correlate, and the model presented a good adjustment to the data: $X2(62) = 153.695$, $p < .001$, $X2/df = 2.48$, $CFI = .938$, $GFI = .907$, $RMSEA = .079$, which indicates the measures' factorial validity.

In this study, *perceived stress* was measured through self-reported anxiety, a negative emotional response to environmental stressors or appraisals (Cohen, Kessler, & Gordon, 1997). Eighteen items from Spielberger's State Anxiety Inventory (Spielberger, Gorsuch, & Lushene, 1970) were used, measured from 1 ("not at all") to 4 ("very much so"). Sample items are "I am tense", and "I feel calm"($\alpha = .90$).

3.4.2. *Room-level variables*

The independent variable was measured at the room-level. Rooms in each hospital were objectively assessed by the researchers in terms of number of favorable elements provided. Table 1 shows the room elements that were assessed (categorized in terms of social support, positive distraction, and perceived control, as classified by participants in a previous study, blind for review), while Table 2 shows the mean numbers of elements for each hospital. All elements were coded 1, except some elements were coded differently to represent the presence or absence of certain components (e.g., the toilet in the room was coded 1 [with shower], 0.5 [with no shower] or 0 [no bathroom]). The number of elements classified to provide social support, positive distraction, and perceived control were highly and significantly correlated (correlations between .68 and .83, all $p < .001$), which suggests the existence of one general factor. Thus, the three variables were collapsed into one single independent variable representing the number of favorable elements in the rooms ($\alpha = .83$).

3.4.3. Analytic strategy

Our data have a two-level hierarchical structure: 187 individuals (at Level 1) who are nested in 57 rooms (at Level 2). In order to analyze nested data, it is necessary to estimate the parameters by taking into account individual differences measures at Level 1, and room differences allocated at Level 2. Accordingly, we estimated a series of multilevel random models using the Hierarchical Linear and Nonlinear Modelling (HLM) software (version 7.01; Raudenbush, Bryk, Cheong, & Congdon, 2013). Models were estimated as either fixed or random error terms on the basis of the statistical significance from preliminary analyses to ensure the convergence of the models (Nezlek, 2001). Level 3 was not considered because the sample size was insufficient to estimate hospital-level effects.

4. Results

4.1.Descriptive and preliminary analyses

Results show that Portuguese patients perceive their rooms as providing more opportunities for Control than do the US patients (M = 3.78, SD = 0.96 vs. M = 3.28, SD = 1.11; F = 10.07, p = .002), and that patients in the US perceive their rooms as providing more conditions for Social Support than do the patients in Portugal (M = 4.61, SD = 0.58 vs. M = 4.37, SD = 0.87; F = 3.86 p =.051) (Table 3). Perceptions on how much Positive Distraction is provided do not differ between countries. US patients report less stress than do the patients in Portugal (M = 1.41, SD = 0.42 vs. M = 1.76, SD = 0.54; F = 19.38, p < .001). Table 3 includes the descriptive statistics by hospital unit and the correlations between the variables. All correlations are in the expected direction, ranging from weak to moderate, which indicates that they are measuring different constructs, avoiding multicollinearity issues.

Before testing our hypotheses, we explored the effect of the Level-2 independent variable (i.e., number of elements in the room) on stress also taking into account the type of

room (i.e., single-, double-, or triple-room). This was done because room occupancy is a relevant environmental factor (Chaudhury, Mahmood, & Valente, 2005) with a potential to influence the experience of patients in terms of the variables under study, and because in Portugal three different types of rooms were included, whereas in the US there were only single rooms. Results showed that only the number of elements of the room (b = -.05, SE = .01, t = - 4.92, $p < .001$) was a significant predictor of stress reduction and not the type of room (b = .02, SE = .06, t = .25, p = .804). Accordingly, the following analysis used the number of elements in the room as the only Level-2 independent variable.

4.2.Effect of hospital rooms and its elements on levels of stress

We started by estimating the single intercept models for stress, Perceived Control, Positive Distraction, and Social Support, with the aim to compute intraclass correlations to describe how much of the total variance of these variables is allocated to room-level. The results show reliable room-level variance for stress (s^2 = 0.03, $p < .05$, intraclass correlation = .11); for Perceived Control (s^2 = 0.14, $p < .01$, intraclass correlation = .14), and for Positive Distraction (s^2 = 0.27, $p < .01$, intraclass correlation = .24), but not for Social Support (s^2 = 0.04, n.s., intraclass correlation = .06). These results indicate that there are variables at the room-level that have an effect on patients' stress and room perceptions, except those related to how much the room contributes to Social Support.

We then regressed stress only on the number of elements in the room. The results show that the regression coefficient is different from zero (b = -.05, SE = .01, t = -5.58, $p <$ .001). As predicted by our first hypothesis, the number of elements in the room explain the variance on stress, which means that the greater the number of elements, the lower the stress.

4.3.Analysis of the mediating role of perceived qualities of the room

To estimate the hypothesized mediation effect, two additional steps followed (Table 4). In the second step, we regressed Perceived Control, Social Support, and Positive Distraction on the number of elements in the room. Results show that the relationship between the number of elements in the room and Social Support (b = .07, SE = .01, t = 7.04, p < .001), and Positive Distraction (b = .08, SE = .02, t = 4.20, p < .001) are positive and significant, i.e., the greater the number of elements in the room, the more participants perceived possibilities for Social Support and Positive Distraction. The number of elements does not reliably predict Perceived Control (b = .04, SE = .02, t = 1.58, p = .12).

Then, we regressed stress on the number of elements in the room and on the mediating variables (i.e., Perceived Control, Social Support, and Positive Distraction). Results show that Social Support (b = -.15, SE = .06, t = -2.56, p = .012) and Positive Distraction (b = -.12, SE = .05, t = -2.37, p = .019) predict a reduction in stress, but not Perceived Control (b = .03, SE = .04, t = 0.74, p = .459) (Figure 1).

These results indicate that the effect of the number of favorable elements in the rooms is mediated by how much Social Support (mediated effect = 0.01; Sobel Test = -2.40, p = .001) and Positive Distraction (mediated effect = 0.01; Sobel Test = -2.07, p = .039) the rooms are perceived to provide, but not by Perceived Control (mediated effect = 0.001; Sobel Test = 0.67, n.s.). Despite the mediating role played by perceptions of the rooms, the direct effect of the room elements on stress is still significant (b = -.03, SE = .01, t = -3.36, p < .001), suggesting that there may be other mediators, not under study, that explain this relationship.

4.4.Analysis of the moderation role of country

The third hypothesis proposes that the mediating role of individuals' perceptions of the rooms may vary according to the cultural context. Accordingly, we re-estimated the

model taking into account the country effect. Country was coded as 0 = US, and 1 = Portugal. The scores of the number of elements and the mediating variables were centered at their grand means. Then, we computed the interaction terms by multiplying country by the number of elements, Social Support, Perceived Control, and Positive Distraction (country x elements; country x Perceived Control; country x Social Support; country x Positive Distraction).

Analyses were carried out in three steps. First, stress was regressed on the number of elements in the room, country, and the interaction term (country x elements). In the second step, Perceived Control, Social Support, and Positive Distraction were regressed on the number of elements in the room, country, and the interaction term (country x elements). Finally, stress was regressed on the number of elements in the room, country, and the interaction term (country x elements), Perceived Control, Social Support, Positive Distraction, and the two-way interaction terms (country x Perceived Control ; country x Social Support; country x Positive Distraction).

The most important results for our proposal are the interaction terms (Table 5). In the first step, the interaction between country and number of elements was not reliable (b = .07, SE = .08, t = 0.91, p = .367), meaning that the effect of the number of elements in the rooms on stress does not vary between countries. In the second step, the interaction term is significant for Perceived Control (b = -.26, SE = .11, t = -2.4, p = .021) and for Social Support (b = -.25, SE = .06, t = -4.35, p < .001), meaning that the effect of the number of elements in rooms on these variables varies between countries, but not for Positive Distraction. Table 5 also shows that the effect of the country is significant on Perceived Control (b = 1.62, SE = .32, t = 5.01, p < .001), Social Support (b = .66, SE = .18, t = 3.69, p < .001), and Positive Distraction (b = .71, SE = .32, t = 2.25, p = .029). As descriptive analyses have already revealed (cf. Table 3), the level of Perceived Control of US patients is lower than that of Portuguese patients, and the level of Social Support of US patients is

higher than that of Portuguese patients, although there are no significant differences on the levels of perceived Positive Distraction. Finally, the results of the third step show reliable interactions between country and each of the mediating variables, indicating that the effects of these variables on stress vary between countries. The interaction term approaches significance for Perceived Control (b = .13, SE = .07, t = 1.95, p = .053), and is significant for Social Support (b = .32, SE = .14, t = 2.35, p = .021), and Positive Distraction (b = -.21, SE = .08, t = -2.51, p = .013).

The reliable cross-level interactions obtained suggest that individuals' perceptions of opportunities provided by the room are moderated by the cultural context. To better interpret these interactions, we decomposed the effects by looking at the mediating role of Perceived Control, Social Support, and Positive Distraction in each country (Figure 2).

In the US, the effect of number of elements on stress is not significantly different from zero (b = -.11, SE = .08, t = -1.39, p = .169). However, the number of elements have a significant effect on Perceived Control (b = .35, SE = .10, t = 3.39, p < .001), and Social Support (b = .31, SE = .05, t = 5.58, p < .001), but not on Positive Distraction (b = .15, SE = .10, t = 1.53, p = .132). Also, results indicate that both Perceived Control (b = -.09, SE = .04, t = -2.55, p = .012) and Social Support (b = -.42, SE = .12, t = -3.59, p < .001) are associated with less stress, whereas perceptions of Positive Distraction do not reliably predict stress (b = -.03, SE = .06, t = 0.5, p = .615). This pattern of results indicates that the effect of the number of elements in the room is mediated by Perceived Control (mediated effect = 0.04; Sobel Test = -2.04, p = .041), and by Social Support (mediated effect = 0.10; Sobel Test = -3.02, p = .003), but not by Positive Distraction (mediated effect = 0.03; Sobel Test = .048, n.s.).

In Portugal, the effect of number of elements on stress is significantly different from zero (b = -.03, SE = .01, t = -3.26, p < .01): the greater the number of elements, the less the stress. Moreover, the number of elements has a significant effect on Perceived Control (b =

.10, *SE* = .02, *t* = 4.03, *p* < .001), Social Support (*b* = .06, *SE* = .01, *t* = 4.216, *p* < .001), and Positive Distraction (*b* = 0.12, *SE* = .02, *t* = 6.72, *p* < .001), which means that the greater the number of elements, the greater the Perceived Control, Social Support, and Positive Distraction. On the other hand, only perceptions of Positive Distraction reduce stress (*b* = -.18, *SE* = .06, *t* = -2.99, *p* = .003), whereas Perceived Control (*b* = .03, *SE* = .05, *t* = 0.622, *p* = .535) and Social Support (*b* = -.10, *SE* = .07, *t* = -1.283, *p* = .202) do not reliably predict stress. These results indicate that the effect of the number of elements in the rooms is mediated by Positive Distraction (mediated effect = 0.03; Sobel Test = -2.73, *p* = .006), but not by Social Support (mediated effect =0.02; Sobel Test = -1.23, n.s.), and Perceived Control (mediated effect = 0.01; Sobel Test = .61, n.s.). Taking into account the perceptions of the rooms, the direct effect of the elements in the room on stress is no longer significant (*b* = -.01, *SE* = .01, *t* = -1.196, n.s.), suggesting that the Positive Distraction perceived to be provided by the room explains this relationship.

5. Discussion

The impact of the physical environment of healthcare settings on patients' stress and well-being has been systematically described in the literature (e.g., Ulrich et al., 2008), but relatively little is known about the mechanisms through which this process is achieved. Also, research has expended little effort to isolate the impact of the design contextual variables. This study tested the theory of supportive design (Ulrich, 1991, 2001) looking at the unique effects of favorable elements in hospital rooms on patients' stress-reduction.

A set of desirable features were counted in hospital rooms located in hospital units from the US and Portugal, and patients recovering in those rooms reported their opinion of how much they perceived the rooms to provide perceived control, social support, and positive distraction, as well as self-reported their level of stress. Using a multilevel approach, we

found that characteristics of the hospital rooms have a significant impact on reported stress. Namely, our analyses indicated that the presence of positive elements (such as artwork, clock, or phone) explain this room effect, meaning that the greater the number of desirable elements in the room, the less the stress.

This study provides further examination of the theory of supportive design and is the first to our knowledge to examine all its three components in a field study. Analyses with the total sample showed that the effects of room elements on patients' stress are in part explained (mediated) by their ability to promote Social Support and Positive Distraction. Consistent with what was found in Andrade and Devlin (2015), Perceived Control did not predict patients' stress. In a hospital, where patients' decision making is constrained, one could hypothesize that the ability to control the physical environment may offer a way to preserve feelings of control over the experience of hospitalization and, thus, reduce stress, but, again this hypothesis was not confirmed. A possible explanation is that control does not always lead to better adjustment, and that it may depend on whether people want to have control (Evans, Shapiro, & Lewis, 1993). Recent research suggested that individual differences in terms of desire for control can have a moderating role on the control-stress link – in that the null effect of control for some people (those low in desire for control) cancel out its positive effect for others (those high in desire for control) (Andrade & Devlin, 2016). Another explanation may be that, overall, environmental control is a less desired or relevant environmental feature compared to the conditions for positive distraction and social support – at least for part of the hospital stay, when patients may feel unwilling to exert effort and prefer or expect to have a more passive role. The recent review by Doherty and Stavropoulou (2012) focusing on the willingness of patients to actively participate in the reduction of medical errors highlights the role that illness may have in affecting the degree to which patients engage with the environment. An additional concern is that greater involvement in

their care may increase levels of fear and anxiety for patients. In this regard, Doherty and Stavropoulou mention that complex stimuli in healthcare settings may create uncertainty for patients with regard to interacting with the setting. Another explanation for passivity in healthcare settings is fear of being labeled as "difficult" by care providers. Further, some research suggests that the longer patients stay in the hospital the greater involvement in care they are likely to exhibit as they become more familiar with their surroundings (Entwistle et al., 2010). In the present study, patients responded to the questionnaire at the beginning of their inpatient room hospitalization, and patients were in the room relatively short periods of time recovering from orthopedic surgery. One might thus expect more desirability of control the longer the patient is hospitalized. More research is needed to investigate the role of environmental control in hospital environments and the circumstances under which patients are likely to exert such control.

This study also shows that perceptions about the room qualities in terms of how much Social Support and Positive Distraction they provide have an impact on patients' stress during their hospital stay. Having social support can ameliorate stress and improve health (e.g., Cohen, 2004), particularly in a potentially unfamiliar and stressful environment such as the hospital, and these findings capture this need. Also, a considerable amount of research has demonstrated the benefits of environmental elements that produce positive distraction, including art, views, virtual reality walks of nature, and videotapes of nature, among other elements (e.g., Schneider, Prince-Paul, Allen, Silverman, & Talaba, 2004; Tse, Ng, Chung, & Wong, 2002; Ulrich & Gilpin, 2003; Verderber, 1986); our study contributes to that body of knowledge.

Interestingly, the moderation analyses revealed a more complex scenario. For the US patients results revealed that the elements in the room produce perceptions that the rooms offer Control and Social Support, and these predict patients' stress-reduction, revealing a

significant mediation. For Portuguese patients, the elements in the room produced perceptions that the room offers possibilities to exert Control, to have Social Support, and Positive Distraction, but only perceptions of how much Positive Distraction is available predict their levels of stress, as these perceptions are a significant mediator. This result, suggesting that conditions for Perceived Control and Social Support are more important for the US sample, and that conditions for Positive Distraction are more important to the Portuguese sample, may indicate that differences in cultural values or expectations produce different environmental perceptions and needs. These differences could perhaps be interpreted in terms of Hofstede's dimensions of individualism-collectivism or power distance levels in the two countries (Hofstede & Hofstede, 2005). However, to draw any conclusions on the reasons for the differences in the results, one would need to test the model with a bigger sample of countries and to have measures of potentially explanatory cultural and contextual variables at the country level.

This research is part of a long tradition of studies in environmental psychology trying to link environmental characteristics to health and well-being. Many of those are focused on specific items of the environment (for instance lighting, e.g., Newsham et al., 2009) but some others (as ours) are framed by theoretical approaches. Among those approaches, the preference matrix proposed by Kaplan and Kaplan (1982, 1987, 1989) was often used. This perspective proposed four attributes of the environment that promote an effective use of the space: coherence and legibility (that enable understanding) and complexity and mystery (that promote exploration). Some of these dimensions can be linked to the dimensions proposed by Ulrich's theory of supportive design used in this paper. For example, the coherence dimension, as it offers a sense of predictability to the experience of space, can be associated to perceived control. And complexity and mystery, giving the sense that there is something to explore, can also be associated with positive distraction. However, the Kaplans' proposal is

particularly suited to natural environments and landscapes. Ulrich's theory of supportive design, in addition to being specifically created for built environments, encompasses more diverse human needs, including the need to belong (social support), the need for control, and the need for stimulation (positive distraction).

The results reported here have certain limitations. The sample size was small, especially in the US. Research conducted in field settings is fraught with challenges, which increase when the data collected are cross-cultural. Despite these challenges, there were aspects of the study where a good deal of control was evident: the fact that all patients underwent orthopedic procedures and that the vast majority of surgeries were for knee and hip replacements, eliminates a number of possible confounding variables.

One should also stress that although our "objective" independent variable (the number of elements present in the rooms) was created in a rigorous and thorough manner, the counting of these elements involved some subjective decisions. The elements in the rooms that were selected to compose our independent variable were those that, from our point of view, and according to previous studies (blinded for review), could operationalize Ulrich's dimensions. Also, the value we attributed to each of the elements was the same (almost always 1 point per element), but different elements may produce different levels of positive distraction, perceived control, or social support. Although our methodology can be critiqued and certainly improved, we believe that we employed an innovative and valid approach compared to the comparison of the "new-old", or "before-after renovation" approaches. To improve reliability, future studies should use interjudge agreement.

Moreover, this study focused on the identification of positive or favorable items in the room that reduce patient stress. It is also possible that not measured negative factors, such as noise, also played a role. Negative elements may for example overshadow the impact of positive design features (see for example d'Astous (2000), in the context of the retail

environment) and should be a focus in future research. In related research in the hospital environment (blinded for review), temperature, cleanliness, and lack of space (among other features) were mentioned as detracting from the quality of patients' experience. These findings support the idea of better understanding not only what contributes to, but also what detracts from, the experience of being hospitalized.

Finally, as mentioned before, we did not measure variables at the country level that could explain the differences between the samples. Thus, future research that examines cross-cultural differences should not only include more countries but explicitly assess variables the literature suggests may vary across cultures in ways that affect outcomes of interest.

In spite of limitations, this study makes an important contribution to the literature. Nevertheless, more rigorous empirical studies are needed to continue to build theories that allow empirically testable predictions that take into account individual and contextual variables.

6. Conclusion

We found evidence that the rooms where patients recover make a difference, and that the favorable elements in the room have an important effect in reducing patients' stress, partially mediated by the perceived qualities of the rooms.

This study overcomes the limitations of previous studies in that contextual (elements in the room) and individual (perceptions about the room) variables are separated to explain patients' stress in the hospital. The study also offered an innovative way to operationalize the quality of the physical environment in a more refined way. Tested for the first time through a field study, this study adds that, at least in part, Ulrich's theory is a reliable approach to understanding underlying psychological mechanisms. In practical terms the research demonstrates that the impact of inpatient room design and the elements it provides matter,

over and above patients' perceptions. Perceived opportunities for control, access to social support, and positive distraction are important, although the relative importance of these dimensions may differ between samples (e.g., culture). Importantly, many of the individual design elements in the rooms in this study are relatively inexpensive, so attention should be paid to these supportive elements as a way to reduce stress.

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Table 1

Room Elements, Organized by Category

Positive distraction	Perceived control	Social support
TV	Whiteboard	Chair for patient [d]
Paintings/ Art	Clock	Chair for visitors
Closet for laundry	Toilet [c]	Internet
Large window [a]	Temperature is adjustable	Phone
View [b]	TV is adjustable	Window bench
	Closet for belongings	
	Extra table	

Note:
[a] 0 - no; 0.5 - yes
[b] 0 - buildings and/or roofscape; 0.5 - streetscape with some natural elements; 1 - nature
[c] 0 - no; 0.5 - yes, but not shower; 1 - yes, with shower
[d] 0 - no; 0.5 - yes, but only one per 2 or 3 patients; 1 - yes, one per patient

Table

Table 2

Descriptive Statistics of Number of Elements in the Rooms per Hospital Unit

	Sum of elements providing Perceived Control			Sum of elements providing Social Support			Sum of elements providing Positive Distraction			Sum of all elements		
Hospital unit	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
US1 (*n* = 5)	6.50	6.50	6.50	3.00	3.00	3.00	1.93	1.00	2.17	12.43	11.50	12.67
US2 (*n* = 15)	7.00	7.00	7.00	4.00	4.00	4.00	3.33	3.00	3.50	15.33	15.00	15.50
PT1 (*n* = 6)	1.33	.00	2.00	2.25	.50	3.00	1.25	.50	2.00	4.83	1.00	7.00
PT2 (*n* = 17)	5.50	5.50	5.50	4.00	4.00	4.00	1.99	1.67	2.17	12.49	12.17	12.67
PT3 (*n* = 14)	5.00	5.00	5.00	4.00	4.00	4.00	1.90	1.33	2.33	11.90	11.33	12.33
Total (*n* = 57)	5.42	.00	7.00	3.73	.50	4.00	2.24	.50	3.50	12.28	1.00	15.50

Table

Table 3

Descriptive Statistics of Individual Level Variables and Correlation Matrix

	Perceived Control (PC)	Social Support (SS)	Positive Distraction (PD)	Stress
	Mean (SD)	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*
Total sample (*n* =187)	**3.62 (1.03)**	**4.45 (0.79)**	**3.40 (1.01)**	**1.65 (0.53)**
US (*n* = 61)	**3.28 (1.11)**	**4.61 (0.58)**	**3.37 (0.97)**	**1.41 (0.42)**
US1 (*n* = 11)	2.41 (1.20)^{a}	3.83 (0.70)^{a}	2.93 (0.99)^{ab}	1.71 (0.61)^{ab}
US2 (*n* = 50)	3.47 (1.01)^{bc}	4.79 (0.39)^{c}	3.46 (0.95)^{bc}	1.35 (0.34)^{a}
Portugal (*n* = 126)	**3.78 (0.96)**	**4.37 (0.87)**	**3.42 (1.03)**	**1.76 (0.54)**
PT1 (*n* = 31)	3.13 (1.05)^{ab}	4.04 (1.05)^{ab}	2.64 (1.00)^{a}	1.98 (0.70)^{b}
PT2 (*n* = 52)	4.00 (0.93)^{c}	4.47 (0.75)^{bc}	3.60 (0.88)^{bc}	1.71 (0.47)^{ab}
PT3 (*n* = 43)	3.99 (0.69)^{c}	4.49 (0.81)^{bc}	3.77 (0.93)^{c}	1.66 (0.45)^{ab}
F (1, 185)	10.07**	3.86 (*p* = 0.051)	0.12 ns	19.38***
F (4, 181)	10.73***	6.77***	8.12***	8.55***
Perceived Control		.51***	.57***	-.21***
Social Support			.52***	-.39***
Positive Distraction				-.38***

Note: Scale values range between 1 and 5 (PC, SS and PD), and 1 and 4 (Stress). The comparison between means was carried out through an ANOVA. * $p < .05$, ** $p < .01$, *** $p < .001$. Means within columns having different superscripts are significantly different according to Scheffé test ($p < .05$) and refer to the different hospital units.

Table

Table 4

Unstandardized Maximum Likelihood Estimated Coefficients Obtained in the Analysis of the Mediating Role of Perceived Qualities of Rooms

	Criterion variables				
Predictors	*Step 1: Stress*	*Step 2: PC*	*Step 2: SS*	*Step 2: PD*	*Step 3: Stress*
Number of elements (NE)	-.05***	.04	.07***	.08***	-.03***
Perceived Control (PC)					.03
Social Support (SS)					-.15*
Positive Distraction (PD)					-.12*

Table

Table 5

Unstandardized Maximum Likelihood Estimated Coefficients Obtained in the Analysis of the Moderating Role of Country

	Criterion variables				
Predictors	*Step 1: Stress*	*Step 2: PC*	*Step 2: SS*	*Step 2: PD*	*Step 3: Stress*
Number of elements (NE)	-.06*	.19***	.15***	.14***	.01
Country (C)	.001	1.62***	.66***	.71*	.41 (*p*=.051)
NE x C	.07	-.26*	-.25***	-.04	-.07
Perceived Control (PC)					-.01
PC x C					.13 (*p*=.053)
Social Support (SS)					-.21**
SS x C					.32*
Positive Distraction (PD)					-.11*
PD x C					-.21*

Figure

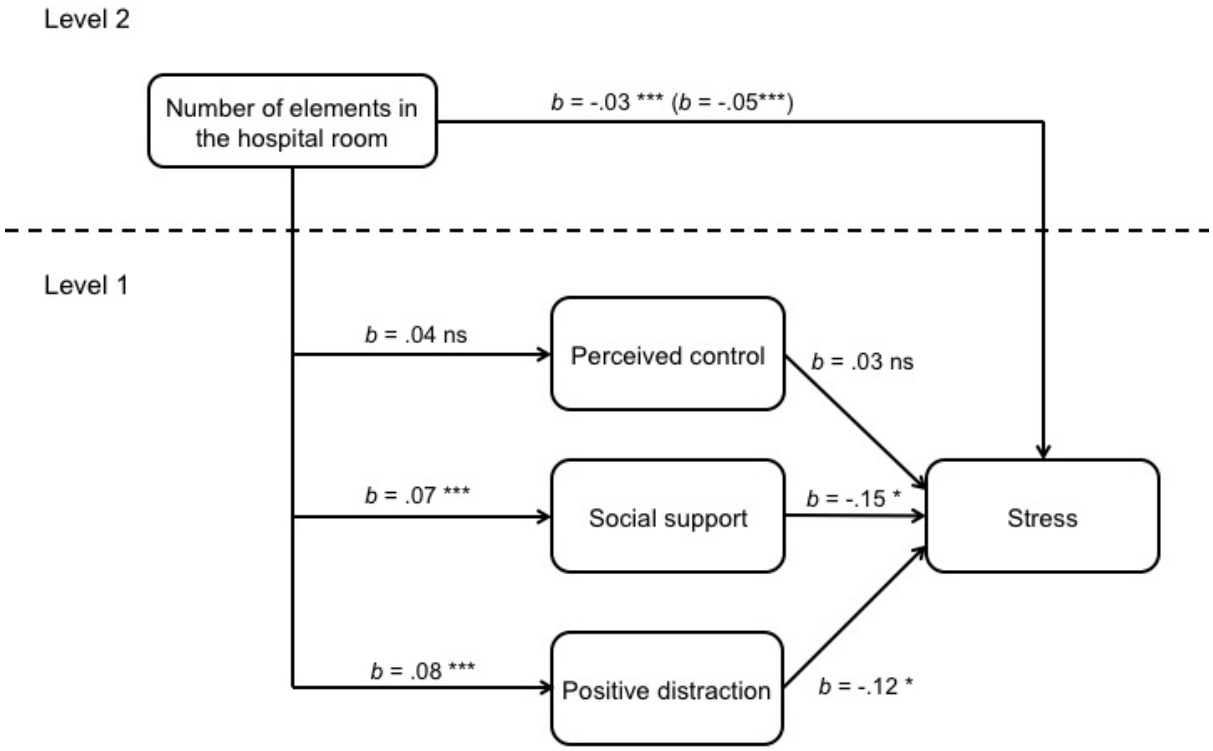

Figure 1. Unstandardized maximum likelihood estimated coefficients for the effect of number elements of rooms on patients' stress, mediated by perceived qualities of rooms *$p < .05$; **$p < .01$; ***$p < .001$.

Figure

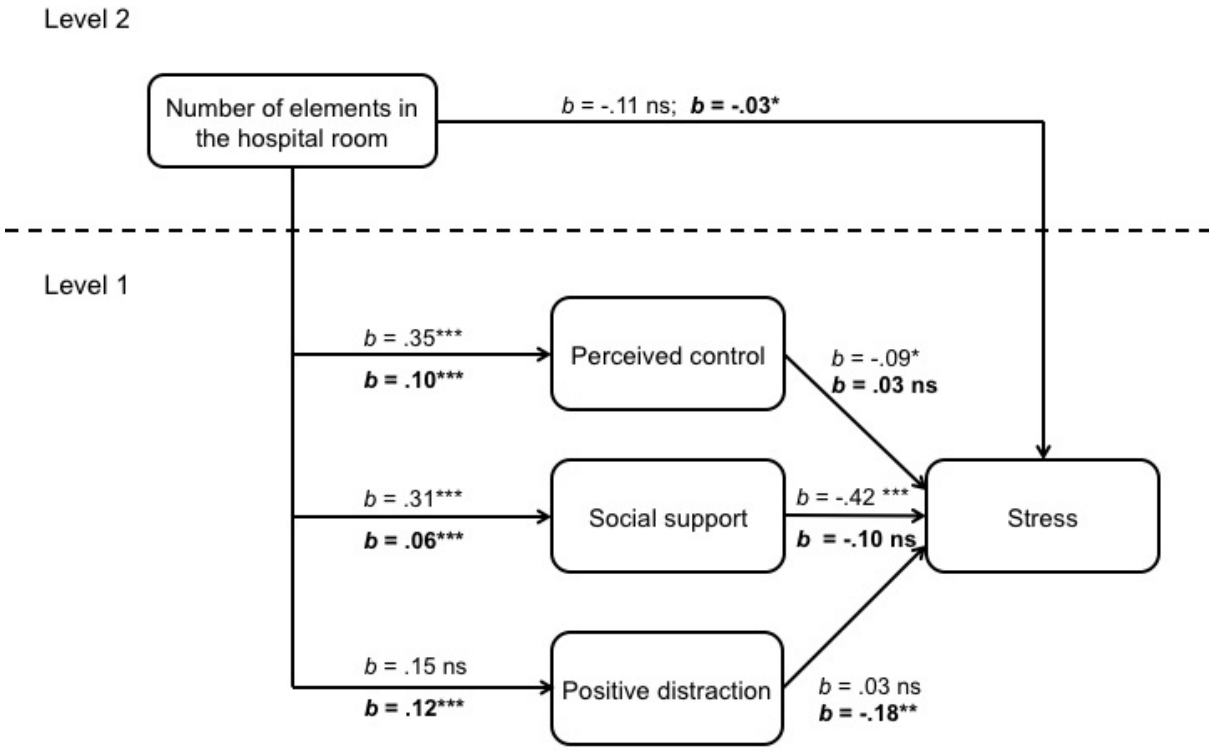

Figure 2. Unstandardized maximum likelihood estimated coefficients for the effect of number elements of rooms on patients' stress, mediated by perceived qualities of rooms and moderated by countries.
The values in regular font correspond to the US and the values in bold correspond to Portugal.
*$p < .05$; **$p < .01$; ***$p < .001$.