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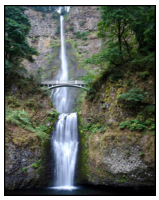

Psychiatric ward design can reduce aggressive behavior☆

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ABSTRACT

The article describes a conceptual model proposing that aggression in psychiatric facilities may be reduced by designing the physical environment with ten evidence-grounded stress-reducing features. The model was tested in a newer hospital in Sweden having wards with nine of the ten features. Data on two clinical markers of aggressive behavior, compulsory injections and physical restraints, were compared with data from an older facility (replaced by the newer hospital) that had only one stress-reducing feature. Another hospital with one feature, which did not change during the study period, served as a control. The proportion of patients requiring injections declined ($p < 0.0027$) in the new hospital compared to the old facility but did not change in the control hospital. Among patients who received injections, the average number of injections declined marginally in the new hospital compared to the old facility, but increased in the control hospital by 19%. The average number of physical restraints (among patients who received at least one) decreased 50% in the new hospital compared to the old. These findings suggest that designing better psychiatric buildings using reasoned theory and the best available evidence can reduce the major patient and staff safety threat posed by aggressive behavior.

11. Introduction

Patient aggressive behavior in psychiatric facilities is a serious and worldwide problem that may be increasing (Bowers et al., 2011). Incidents of violence are alarmingly prevalent and cause psychological harm and often physical injury to patients and staff. A review of 122 studies carried out in 11 countries (among others, United States, United Kingdom, Australia, Sweden, Germany, Netherlands) found that 32.4% of patients admitted to psychiatric facilities engaged in aggressive behavior or violence (Bowers et al., 2011). The mean incidence of violent events internationally per 100 patients sampled randomly was 224. Rates are somewhat similar across different countries but vary by type of psychiatric diagnosis and treatment setting (Bowers et al., 2011). Variation also arises from the use of different definitions and measures of aggression and violence in clinical reporting and studies.

Nearly 50% of all aggressive incidents recorded in psychiatric facilities internationally involve physical violence. On average 62% of nurses in different countries indicate they have experienced physical violence over the course of a year (Bowers et al., 2011). Similarly, a study of psychiatric personnel in Sweden (731 nurses, 320 psychiatrists) found that 57% had been the target of physical violence in the past 12 months (Soares, Laoko, & Nolan, 2000). International data suggest that *37% of violent or aggressive incidents result in physical injury to staff* (Bowers et al., 2011), an alarming figure that underscores the seriousness of aggression as a staff as well as patient safety hazard.

Much research in psychiatry to predict and reduce aggressive behavior has focused on patient characteristics (such as diagnosis or history), as well as improvements to staff training and care processes (Daffern & Howells, 2002; Dolan, Fullam, Logan, & Davies, 2008; Forster, Cavness, & Phelps, 1999; Privitera, Weisman, Cerulli, Tu, & Groman, 2005). By contrast, few studies have examined the possible influence of architectural features on outcomes (Papoulias, Csipke, Rose, McKellar, & Wykes, 2014). There is also a lack of reasoned and plausible theory for designing psychiatric facilities to lessen aggression. As a result, best practices for designing psychiatric facilities traditionally have been based on clinical conjecture, anecdote, and experience,

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and have not provided explicit design recommendations for reducing aggression and physical violence (Connellan et al., 2013; Karlin & Zeiss, 2006). The lack of theory and research evidence has often limited design for aggression reduction to security features and damage-resistant components: locks, observation windows and cameras, violence proof doors and walls, metal detectors, and isolation rooms. These measures continue to be important, but the apparent continued high incidence of aggressive behavior and violence suggests that reliance on traditional architectural and clinical approaches is not enough.

The article has two main objectives. First, to address the lack of plausible architectural theory in psychiatry a conceptual model for designing wards to reduce aggression and violence is proposed. The model posits that environmental and psychosocial stressors trigger aggressive behavior; therefore, violence could be reduced if the facility has been designed with several evidence-grounded stress-reducing environmental features (Ulrich, Bogren, & Lundin, 2012). Subsequent sections discuss each environmental variable in the model and cite relevant research drawn from environmental psychology, evidence-based healthcare design, psychiatry, and other fields. The last sections address the second main objective, which is to provide an empirical evaluation of the model based on a study of aggressive incidents in psychiatric hospitals that varied widely with respect to the environmental features in the model but were similar in non-environmental factors known to influence aggression.

2. Research on psychiatric ward design and aggressive behavior

Two studies represent a beginning towards addressing the need for research on the link between environmental features and aggression in psychiatric wards. A cross-sectional study of 199 wards in Dutch hospitals reported that certain design factors were associated with reduced seclusion risk ("ward visibility" characteristics such as good sight lines and overview); others to increased risk ("special safety measures" such as door locks with delayed opening) (van der Schaaf, Dusseldorp, Keuning, Janssen, & Noorthoorn, 2013). However, lack of variation across the facilities with respect to certain design characteristics, such as proportion of single versus shared bedrooms (93.6% were singles), likely obscured the possible influence of the factors on seclusion risk. A study in England compared aggression in an old psychiatric care unit with levels in a new unit having environmental improvements that included, for example, single rooms and increased levels of visibility ("clear sight lines") (Jenkins, Dye, & Foy, 2015). Findings suggested that aggression was lower in the new ward compared to the old as evidenced by reductions in aggressive incidents and seclusion rates.

2.1. Ward crowding and aggression

Crowding is the only environment-related variable to receive attention in multiple studies of aggressive behavior in psychiatric wards. Some researchers have proposed that ward crowding should foster increased aggression by exposing patients to negative or stressful conditions such as higher stimulation levels, ward turmoil, and lack of privacy (Brooks, Mulaik, Gilead, & Daniels, 1994; Chou, Lu, & Mao, 2002; Daffern, Mayer, & Martin, 2004; Palmstierna, Huitfeldt, & Wistedt, 1991). Unfortunately, studies in psychiatric facilities have not measured crowding in ways that explicitly consider environmental factors and rarely contain description of the physical environments of wards. Some aggression studies in psychiatry have defined crowding as a high ward bed occupancy rate (Brooks et al., 1994; Virtanen, Vahtera, Batty, Tuisku, Pentti, Oksanen, Salo et al., 2011), while others have mixed different terms such as crowding, ward space, downsizing, patient density, or ward density (Flannery et al., 1997; Nijman & Rector, 1999; Snyder, 1994). Many reports refer to "density" but do not clearly define the concept. The failure to define terms and describe features of the physical environment has made it difficult for researchers in other fields and healthcare architects to interpret findings on crowding and aggressive behavior in psychiatric facilities. Across studies in psychiatric facilities there is no consistent association between crowding defined as high ward occupancy and aggression/violence. Some investigations have reported a modest to strong positive link with aggressive behavior, while others have reported no correlation (Brooks et al., 1994; Hardie, 1999; Lanza, Kayne, Hicks, & Milner, 1993; Ng, Kumar, Ranclaud, & Robinson, 2001; Nijman & Rector, 1999; Palmstierna & Wistedt, 1995; Palmstierna et al., 1991; Virtanen et al., 2011).

Crowding theory and research in environmental psychology may be helpful for explaining the lack of consistent association in psychiatry studies between ward occupancy rates and aggressive behavior. There is much evidence that crowding stress and related aggression are linked to inadequacies in the physical environment that constrain the ability of persons to seek privacy, regulate their relationships with others, and avoid stressors such as noise and arguments (Baum & Paulus, 1987; Baum & Valins, 1977; Cox, Paulus, & McCain, 1984). In contrast to psychiatry, environmental psychology has distinguished between *spatial density* and *social density* (Baum & Paulus, 1987; Stokols, 1972). Spatial density is defined as the amount of space (square meters or feet) per person in a physical environment, while social density usually refers to the number of persons per room. Studies carried out in non-hospital environments as varied as apartments and prisons have shown that the most consistently important variable for predicting crowding stress and aggressive behavior is the number of persons per room (social density), and spatial density is relatively unimportant unless space per person becomes constricted (Baum & Paulus, 1987; Cox et al., 1984; Evans, 2003). Beyond social density, research in environmental psychology and other fields suggests that a conceptual model for designing psychiatric facilities to reduce stress and aggression should prominently include other environmental features that enable patients to seek privacy, regulate interpersonal interactions, avoid stressors, and experience stress-reducing positive distractions such as nature (Baum & Paulus, 1987; Ulrich, 1991; Ulrich et al., 2012; Wener, 2012).

3. Conceptual model for designing psychiatric wards to reduce aggression

A major consideration in developing the model was to identify design features sufficiently well-defined to enable both replication by researchers and practical use by designers. For a design feature to be included, there should be credible empirical evidence suggesting that changes in the variable are linked with clearly measurable changes in stress or aggression. The model should be based on plausible and logically consistent reasoning, and generate falsifiable predictions for future studies.

A key premise underlying the facility design model is that the stressors experienced by psychiatric inpatients foster and trigger aggression. A second proposition is that the ward physical environment strongly influences patient stress. A poorly designed facility that prevents privacy, is noisy, and has other stressful features can intensify the stress of mental illness and involuntary confinement, thereby worsening aggression. Architecture can perhaps reduce aggression if deliberately designed to minimize stressors such as crowding and noise, and offer stress-reducing positive distractions (Ulrich, 1991; Ulrich et al., 2008). Although the conceptual model emphasizes the role of the built environment in reducing stress and violence, it is also recognized that the competence and experience of clinicians, quality of treatment protocols, and other non-environmental variables influence these outcomes (Ulrich, Berry, Quan, & Parrish, 2010).

The premise that stress causes and worsens aggression is reflected in explanatory models of violence on inpatient psychiatric wards (Nijman, à Campo, Ravelli, & Merckelbach, 1999; Nijman, 2002; Kumar & Ng, 2001). These conceptual frameworks include the environment as a variable influencing stress, placing emphasis on stress resulting from crowding or high bed occupancy rates. It appears that no randomized

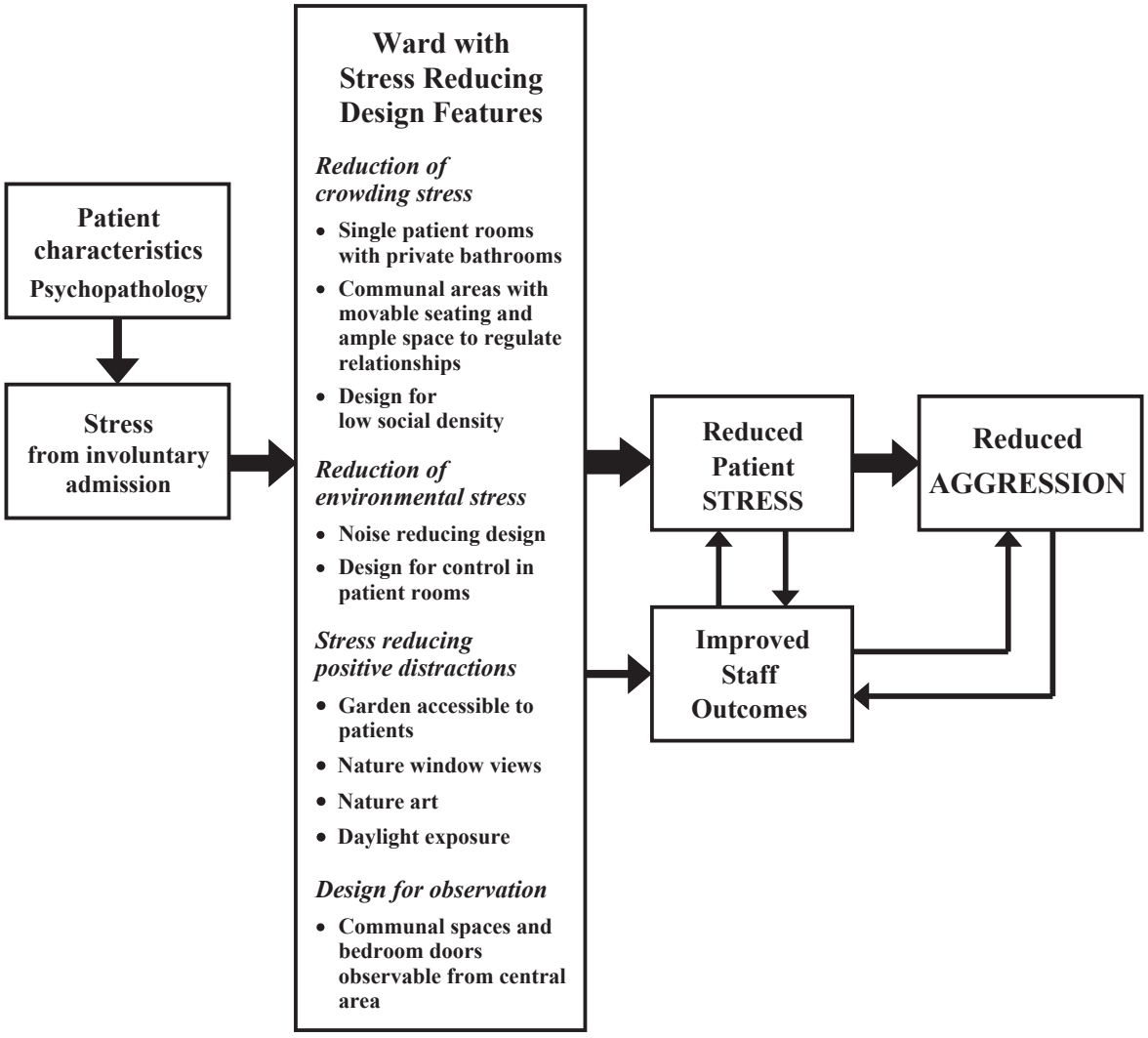

Fig. 1. Conceptual model for designing inpatient psychiatric wards to reduce aggression.

study of individuals in inpatient psychiatric wards has yet directly examined the possible causal link between stress-provoking events and aggression behavior, perhaps because of ethics concerns. However, a randomized study of non-patient volunteers produced strong evidence that stress triggers and worsens anger reactions, particularly in higher trait anger individuals (Kweon, Ulrich, Walker, & Tassinary, 2008). The stress-aggression link for psychiatric patients received convincing support from a study of individuals born in Sweden who were diagnosed either with schizophrenia, bipolar disorder, or had no psychiatric diagnosis and served as controls (Sariasian, Lichtenstein, Larsson, & Faze, 2016). Findings showed that exposure to major stressors (particularly violence) significantly increased risk for patients with psychosis to commit aggressive acts during the first week following exposure.

Fig. 1 outlines the proposed model for designing psychiatric facilities to reduce aggression. The lines and arrows in the figure indicate posited relationships among the main variables (see box labels). Beginning with the left-most boxes, the model is similar to an aggression framework developed by Nijman and colleagues in positing that the patient's stress accompanying acute psychopathology is intensified by stressors associated with involuntary or compulsory admission to a psychiatric ward (being locked up, for example) (Nijman et al., 1999). Moving to the right in the figure, this environmental model becomes quite different from traditional psychiatric models by proposing that the patient's acute stress will be lessened after admission–in contrast to intensified–if the facility has been designed in evidence-informed ways to mitigate stressors and promote exposure to stress-reducing features such as nature. The box in Fig. 1 labeled Ward with Stress Reducing Design Features lists ten environmental factors; most are gleaned from decades of research in environmental psychology and evidence-based design of general or somatic hospitals. The stress-mitigating design features are grouped into four conceptual categories (Fig. 1): reduction of crowding stress (three design features); reduction of environmental stress (two features); stress-reducing positive distractions (four features); and design for observation (one feature). The last, observation, is considered to indirectly lessen patient stress by facilitating staff capability to supervise patients and anticipate and prevent aggressive behavior.

The model proposes that implementing several of the design features in a psychiatric facility will reduce stress and aggression more effectively than a single design intervention. This approach to healthcare design advocating a cluster of specified environmental interventions echoes the widespread adoption in medicine (including psychiatry) of specified clinical intervention bundles to achieve greater efficacy (Hamilton, 2010).

The model posits that the physical environment lessens patient stress, leading to reduced aggression. This can be reflected in different outcome improvements, such as reduced verbal aggression, physical violence, less use of compulsory injections, physical restraints, seclusion, and fewer injuries to patients and staff. The stress-reducing environmental features directly and positively influence staff, for

example, by reducing work-related stress and fostering higher work satisfaction and retention. Diminished patient stress and aggressive behavior are considered to feed back positively on staff, improving staff outcomes and fostering better care that further helps lessen patient stress and aggression.

The next section discusses each feature in the Ward Stress Reducing Design Features box in Fig. 1. The purpose is to give an introduction to each environmental variable and cite research examples, not provide comprehensive reviews. (For more detailed research reviews of some of the design factors see Baum & Paulus, 1987; Ulrich et al., 2008; Wener, 2012.)

4. Design features that reduce stress and foster diminished aggression

4.1. Reduction of crowding stress

4.1.1. Single patient rooms with private bathrooms

Single bedrooms with private bathrooms may be the single most important design intervention for facilitating privacy access and reducing crowding stress and aggression in inpatient psychiatric wards. Considerable research on apartments and correctional facilities has shown that the number of persons sharing a bedroom or cell reliably correlates with higher crowding stress, reduced privacy, more aggressive behavior, illness complaints, and social withdrawal (Baron, Mandel, Adams, & Griffen, 1976; Baum & Valins, 1977; Cox et al., 1984; Paulus, 1988; Schaeffer, Baum, Paulus, & Gaes, 1988). These findings emerge when studies control for spatial density or the amount of space per person in bedrooms or cells. Research on psychiatric inpatient wards suggests a strong association between multi-bed rooms and social withdrawal (Ittelson, Proshansky, & Rivlin, 1972). Stolker and colleagues have contended that multi-bed rooms deprive psychiatric patients of privacy and rest, and this accounts for the finding that patients who share a room with other patients are less negative about seclusion or isolation than patients who reside in single rooms (Stolker, Nijman, & Zwanikken, 2006). A study of 92 inpatient wards in England found that provision of single rooms and private bathrooms for patients was associated with higher staff satisfaction with the built environment (Sheehan et al., 2013). While some researchers and architects in the United States have argued that the presence of a roommate in psychiatric facilities enhances supervision of patients at risk of suicide (Shepley et al., 2016), national guidelines in several European countries including Sweden require that such patients be continuously monitored by a qualified staff member. This enables single rooms to be used both to prevent self-harm and reduce crowding.

4.1.2. Communal areas with movable seating and ample space to regulate relationships

The conceptual model proposes that it is also important to have communal areas with movable seating, seating choices, and ample space to enable patients to regulate personal space and interactions with others. Personal space intrusions provoke flight or avoidance behavior in psychiatric patients (Felipe & Sommer, 1966) and can trigger aggression (Fagan-Pryor et al., 2003). Psychiatric patients and prisoners with a history of aggressive behavior require greater personal space distances than those with nonviolent histories (Kinzel, 1970; Walkey & Gilmour, 1984). This implies the importance of providing ample space per patient in shared seating areas and activity rooms to support the greater personal space distances than many patients presumably need. Movable in contrast to fixed chairs facilitate personal space regulation, promote positive interpersonal interaction, and may reduce aggressive behavior in communal spaces of psychiatric facilities (Baldwin, 1985; Holahan, 1972; Sommer & Ross, 1958).

Although fixed seating might lessen risk that specific chairs are used in violent acts in spaces such as psychiatric emergency units and intake areas, studies of new (third) generation U.S. federal correctional facilities have produced no evidence that movable or regular chairs are used as weapons (Tartaro & Levy, 2007; Nelson, 1988; Wener, 2012). Research on other types of violence-proof design elements (doors and frames, walls, locking devices) suggests these features are linked with significantly *increased* levels of ward aggressive behavior and seclusion (van der Schaaf et al., 2013).

4.1.3. Design for low social density

The conceptual model may be the first for designing healthcare facilities that includes social density, explicitly defines the concept for psychiatric wards, and proposes why this design characteristic can be linked to crowding stress and aggressive behavior. It is posited that social density is a broad indicator of the extent to which psychiatric ward architecture facilitates or hampers patients' ability, by *moving between different rooms*, to regulate relationships and room group size, access privacy, and avoid stressors. Ward social density is defined here as the number of patients (assuming 100% occupancy) divided by the total number of rooms accessible to patients – that is, the number of patients per room. Rooms included in the definition proposed here are private and shared bedrooms, private and shared toilets and showers, day rooms, and other communal spaces such as kitchens or activity rooms. A garden is counted as a communal space (or room) only if it is unlocked, accessible to patients without staff escort, and contains seating.

The definition does not consider corridors to be rooms and excludes these spaces in calculating ward social density. Corridors are regarded as movement paths with narrow dimensions that can exacerbate personal space intrusions and trigger aggressive behavior. This interpretation is supported by evidence showing that corridors stand out as the location of many aggressive incidents in psychiatric wards and adolescent treatment facilities (Chou et al., 2002; Deitch, Madore, Vickery, & Welch, 2013; Lanza et al., 1993; Vivian, Grimes, & Vasquez, 2007). For example, a study of six psychiatric units found that 38% of assaults and other aggressive incidents occurred in corridors (Lanza et al., 1993). Another drawback is that fire codes often prevent placement of seating and other furniture in corridors of locked institutional facilities.

Consistent with crowding research showing that social density is an important predictor of stress and aggressive behavior (Baum & Paulus, 1987; Evans, 2003), the conceptual model proposes that psychiatric wards designed in ways that ensure fewer patients than rooms should tend to mitigate both. Even if occupancy escalates to 100%, a ward with single bedrooms, private bathrooms, and several communal spaces – compared to wards with multi-bed rooms, shared bathrooms, and few communal rooms – can maintain a low social density of < 0.5 patient per room, indicating the physical environment will continue to make it possible for patients to regulate relationships and avoid unwanted contacts by moving between rooms. Additionally, the conceptual model predicts that the association between high social density and crowding stress (and aggressive behavior) will be intensified if communal rooms are designed with features that hamper regulation of relationships and worsen personal space intrusions *within* the rooms, such as restricted space per patient and fixed seating.

4.2. Reduction of environmental stress

4.2.1. Noise reducing design

Randomized studies of non-patient volunteers have provided strong evidence that exposure to uncontrollable or unpredictable noise increases stress, triggers aggression, and worsens retaliatory aggression (Geen, 1978; Geen & McCown, 1984; O'Neal & McDonald, 1976; Donnerstein & Wilson, 1976). In addition, much evidence has shown that high noise in general hospitals is a pervasive environmental stressor that worsens patient outcomes and negatively impacts staff (Busch-Vishniac et al., 2005). It is thus puzzling that research is lacking on the effects of noise in psychiatric wards on clinical outcomes, given

that noise levels in psychiatric facilities can be at least as high as in general hospitals (Holmberg & Coon, 1999). Noise-reducing design in somatic hospitals lowers psychological and physiological stress in patients and improves other clinical outcomes (Hagerman et al., 2005; Hsu, Ryherd, Waye, & Ackerman, 2012). It also lessens stress and perceived work demands in staff, increases speech intelligibility, and improves communication quality with patients (Blomkvist, Eriksen, Theorell, Ulrich, & Rasmanis, 2005; Ryherd, Okcu, Ackerman, Zimring, & Waye, 2012; Topf & Dillon, 1988). Design measures found effective for reducing noise and enhancing acoustic privacy in non-psychiatric hospitals include, among others, providing single-bed rooms with walls and doors that block noise, and sound-absorbing environmental surfaces that diminish echoing and propagation of noise (MacLeod, Dunn, Busch-Vishniac, & West, 2007; Ulrich et al., 2008).

4.2.2. Design to foster control in patient rooms

Evidence-grounded theory in healthcare design holds that one important way design can reduce patient stress is by fostering sense of control over physical surroundings (Andrade & Devlin, 2015; Ulrich, 1991). Exposure to environmental conditions not under personal control can be stressful; for example, television played uncontrollably in a healthcare waiting room can worsen patient stress (Ulrich, Simons, & Miles, 2003). Although some of the ward features discussed above enhance control (noise reduction, single rooms for privacy), the focus here is on design elements within patient rooms (Ulrich, 1991). The conceptual model proposes that design features that enable patients to control or personalize their rooms will support stress coping and help diminish aggressive behavior. Examples of features presumed to enhance control in bedrooms include a window that can be partly opened, controllable lighting, and personalization opportunities such as pictures (Andrade & Devlin, 2015; Ulrich, 1991). A study of Dutch psychiatric wards found that control-related design features in patient rooms (operable windows, for example) were associated with significantly lower seclusion risk (van der Schaaf et al., 2013). However, other research on non-psychiatric patient rooms raises the possibility that control features, if complicated and difficult to operate, may erode control and not reduce stress (for example, a complicated remote control for temperature and lighting) (Andrade & Devlin, 2015).

4.3. Stress reducing positive distractions

4.3.1. Garden accessible to patients

Patients, visitors, and staff in general hospitals who use gardens report reduced stress and improved emotional well-being (Marcus & Barnes, 1995; Sherman, Varni, Ulrich, & Malcarne, 2005; Whitehouse et al., 2001). Studies in general hospitals suggest that gardens designed in informal natural styles with prominent vegetation and flowers are more effective in reducing stress than structured or geometric gardens with prominent hardscape such as concrete (Marcus & Sachs, 2014; Shukor, 2012; Twedt, Rainey, & Proffitt, 2016). Although a window view of nature can reduce stress (see next section), physical access to a garden appears more effective in fostering restoration from stress (Largo-Wight, Chen, Dodd, & Weiler, 2011; Lottrup, Grahn, & Stigsdotter, 2013). Conversely, a cross-sectional study of psychiatric wards found that gardens were associated with higher seclusion risk; however, this study did not record whether gardens were locked and inaccessible, and lack of variation across facilities with respect to garden presence may have negatively biased the findings (van der Schaaf et al., 2013). It is thus proposed here that providing unlocked gardens that are accessible to psychiatric inpatients can foster stress reduction by providing nature views, enhancing control, and offering pleasant places to seek privacy or socialize (Ulrich, 1999). However, there is no credible basis for expecting that a garden will be frequently used and effective for reducing stress if it is locked and access requires time-consuming escort by busy staff of patients by elevator or through hallways. (Patients with serious mental illness often must be escorted individually.)

4.3.2. Nature window views

Prospective controlled studies of somatic hospital inpatients and non-patient groups have found that viewing nature reduces psychological and physiological stress, and diminishes anger in persons exposed to anger-provoking stressors (e.g., Brown, Barton, & Gladwell, 2013; Kweon et al., 2008; Ulrich et al., 1991). Research on nurses in general hospitals and office workers suggests that those having daily exposure to a nature window view in their work areas report lower work-related stress and higher satisfaction than employees having a built environment view or no window (Leather, Pyrgas, Beale, & Lawrence, 1998; Lottrup, Stigsdotter, Meilby, & Claudi, 2015; Pati, Harvey, & Barach, 2008).

4.3.3. Nature art

Research suggests that representational nature art should be considered for psychiatric wards while abstract artwork should be used with caution. A retrospective study reported that psychiatric inpatients physically attacked certain abstract but not nature artworks (Ulrich, 1991). A prospective study of psychogeriatric inpatients found that placing a realistic nature poster in a ward dayroom was more effective in reducing injections for aggressive behavior than abstract art or a control condition of no art (Nanda, Eisen, Zadeh, & Owen, 2011). Parallel findings were obtained in a randomized trial of non-patient volunteers exposed to anger-provoking tasks (Kweon et al., 2008). Studies of art preferences in somatic hospitals have consistently found that the great majority of patients prefer realistic nature art but most dislike images that are abstract, surreal, or display emotionally negative subject matter (Carpman & Grant, 1993; Nanda, Eisen, & Baladandayuthapani, 2008; Ulrich & Gilpin, 2003).

Research in neuroscience and visual perception provides additional support for the recommendation that nature art should be specified for psychiatric facilities, while many abstract artworks and scenes lacking nature should be avoided. This research is consistent with the idea that the human visual system evolved to efficiently process natural scenes, and that images with “unnatural” characteristics can be taxing and physiologically stressful to the visual system and brain, in part because they display contrasting elements with unnatural spacing and patterning to which the visual system is negatively sensitive (Fernandez & Wilkins, 2008; Párraga, Troscianko, & Tolhurst, 2000).

4.3.4. Daylight exposure

It appears that no study has yet investigated whether daylight levels influence aggression in psychiatric hospitals. However, research on Alzheimer's patients suggests that agitation levels may be lower in facilities having higher interior light exposure compared to buildings with less light (Sloane et al., 1998). Assigning psychiatric inpatients with serious depression to rooms with higher daylight may shorten stays compared to placing similar patients in rooms that receive less daylight or are always in shade (Beauchemin & Hays, 1996; Benedetti, Colombo, Barbini, Campori, & Smeraldi, 2001). Regarding staff, nurses with higher access to daylight in work areas, compared to those working in spaces far from windows, report less work stress, better health status, and higher satisfaction (Alimoglu & Donmez, 2005; Mroczek, Mikitarian, Vieira, & Rotrius, 2005).

4.4. Design for observation

4.4.1. Good visibility from central area of communal areas and bedroom doors

Design to facilitate observation supports staff capability to anticipate and prevent aggressive behavior. Findings from two studies suggest that design for good visibility reduces aggressive behavior and seclusion risk in psychiatric wards. Jenkins et al. (2015) compared aggressive behavior in an old versus new facility with increased visibility as measured by “all areas of the ward being visible from the staff base” and “clear lines of sight.” van der Schaaf et al. (2013) compared

Table 1
Comparison of ward environments in Old, New, and Control hospitals with respect to stress-reducing environmental features in the conceptual model.

Stress reducing design features in model		Old hospital	New hospital	Control hospital
Reduction of crowding stress	**Single bedrooms (number of 1-bed and multi-bed rooms per ward)**[a]	1-bed: 8 4-bed: 2	1-bed: 10 2-bed: 2	1-bed: 2 2-bed: 1 4-bed: 2
	Private bathrooms	2	10	0
	Shared bathrooms	3	2	3
	Communal areas with movable seating and ample space to regulate relationships[b]	movable: no spacious: yes	movable: yes spacious: yes	movable: mixed spacious: no
	Number of seating/activity areas	6	11	3
	Low social density (fewer patients than rooms at 100% occupancy)	0.76 patient/room	0.40 patient/room	1.09 patient/room 1.00 (2005)
	Adjusted for average occupancy[c]	0.68 (2005)	0.36 (2007)	1.05 (2007)
Reduction of environmental stress	**Noise reducing design**	no	yes	no
	Design for control in patient rooms	no	yes	no
Stress reducing positive distractions	**Garden accessible to patients**	no	yes	no
	Nature window views	some	yes	no
	Nature art, not abstract	mixed	mixed	mixed
	Design for higher daylight exposure	no	yes	no
Design for observation	**Observation from central area to bedroom doors and communal areas**	bedroom drs: yes communal: no	bedroom drs: yes communal: yes	bedroom drs: yes communal: no
	Ward floor plan type	corridor-based	central area	corridor-based

[a] Ward layouts and bedroom mix varied somewhat in Old and Control hospitals but not in New. Table 1 represents the environmental features of a representative or typical ward in each facility.

[b] See Table 2 for space comparisons.

[c] Occupancy rates: Old 2005, 89.7%; Control 2005, 91.3%; New 2007, 91.0%; Control 2007, 95.9%.

wards with respect to visibility, ranking higher those having cameras, wide corridors, and good overview and sight lines. In addition, floor layouts arranging patients rooms around a central area for observation, compared to corridor-dominated ward designs, were found to increase staff satisfaction with the physical environment (Sheehan et al., 2013). Other design approaches recommended as best practice for facilitating observation in locked treatment facilities include, for example, providing walls of damage-resistant glazing between communal spaces (Roush & McMillen, 2000).

The effectiveness of design for observation in reducing aggression may be linked with characteristics of the staff model for supervising and monitoring patients. The supervision model used in Swedish psychiatric hospitals (and other northern European countries) directs staff to spend "as much time as reasonably possible" outside offices or workstations monitoring patients and interacting with them directly (not through glass) on an individualized basis,[1] while patients roam about shared areas. This requires staff to move about the ward while maintaining observation over day rooms, activity spaces, corridors, and bedroom doors. Staff is trained to monitor patients unobtrusively (for example, not staring directly at individuals), detect and respond to problems, and intervene proactively to prevent aggressive behavior. (As mentioned, patients at risk of suicide are continuously monitored.)

Empirical research is lacking for psychiatric facilities concerning the effects of combinations of changes in observation characteristics and supervision models on stress and aggressive behavior. However, these issues have been examined in studies of new (third) generation correctional facilities in the U.S. federal system (Nelson & O'Toole, 1983; Wener, Frazier, & Farbstein, 1985; Senese, 1997; Wener, 2006). Beyond differences between the two types of facilities,[2] several similarities can be identified as well. First, aggressive behavior is a prevalent and serious problem in both types of facilities. Second, staff is located outside workstations where they interact directly with inmates and can proactively respond to problems before they escalate into aggression (Nelson & O'Toole, 1983). Third, to create good sightlines and support a direct supervision model, floor layouts arrange single-bed cells around large central areas, with no corridors and no staff stations. Studies have reported that aggressive behavior and vandalism are substantially reduced in correctional units having central area layouts, compared to aggression levels in earlier generation correctional units with corridors and enclosed observation stations (Nelson & O'Toole, 1983; Senese, 1997; Wener, Frazier, & Farbstein, 1987, pp. 1–23). Inmates and staff report feeling less stressed, safer, and more secure (Wener, 2006; Williams, Rodeheaver, & Huggins, 1999). This research is consistent with the interpretation that inmates may be receptive to (and feel more secure) being under observation in shared spaces if supervision by staff is direct and proactive, inmates can access privacy in their cells, and the incidence of aggressive behavior and violence is low.

5. Methods: empirical assessment of conceptual model

5.1. Hypotheses and research design

Our main hypothesis was that the incidence of aggressive behavior would be lower in a psychiatric hospital with wards having several of the design features in the model compared to hospitals with few of the features. To test the hypothesis, aggressive incidents in hospitals that differed widely with respect design features in the model but were similar in non-environmental variables known to influence aggressive behavior (patient, staff, and care protocol factors) were compared. A newer psychiatric hospital (New) in Gothenburg, Sweden that opened in 2006 was evaluated as having wards with nine of the ten design features identified as likely to reduce stress and aggression (Table 1), and compared with data from an older facility (Old) that the newer hospital replaced, with only one of the features. Data on two reportable clinical markers of aggressive behavior – compulsory injections and physical restraints – were compiled retrospectively for both hospitals (Table 1).

To strengthen the Old/New hospital comparison research design, another psychiatric hospital served as a control (Campbell & Stanley, 1963). The control hospital (Control), which did not undergo replacement or refurbishment during the period of the study, had wards with

[1] The description of the model for supervising and monitoring patients in wards is based on interviews with several clinicians and ward managers in psychiatric facilities in Sweden.

[2] A difference between psychiatric wards and new generation U.S. federal correctional units is that ward group sizes are smaller (Wener, 2006). Another difference is that the ratio of staff to patients in psychiatric wards is higher than the ratio of staff to inmates in new generation prisons (Wener, 2006).

only one of the environmental features identified as likely to reduce stress and aggression (Table 1). We hypothesized based on the model that the incidence of aggressive behavior would not change in the Control hospital during the period of the study (2005–2007).

Despite substantial differences in design, the three hospitals (Old, New, Control) were in the same catchment/service area and governed by the same regional healthcare authority. They were thus similar with respect to care and monitoring protocols, and pharmacological treatment. More than 90% of the staff in New (2007) had previously worked in Old, which closed in 2006.[3] Patient data were obtained for compulsory care[4] patients in the same diagnostic categories in the three hospitals (schizophrenia or other psychosis, bipolar disorder, personality disorder, or high suicide risk). The high-acuity compulsory care status of the patients meant there were essentially no private hospital alternatives to the public sector hospitals in the study (Old, New, and Control). Occupancy rates across the hospitals were comparably high during the period of the study, ranging from 89.7% to 95.9% (Table 1). No major changes in any of the above variables occurred between 2005 and 2007.

5.2. Comparison of ward design features in study hospitals

Examination of Table 1 shows that wards in New hospital were superior to those in Old and Control with respect to all four conceptual categories of stress-mitigating design features in the model: crowding stress reduction; environmental stress reduction; stress reduction via positive distraction; and design for observation. In particular, New wards were better in having design characteristics identified as important for reducing crowding stress, including single rooms with private bathrooms, communal areas with choices of movable seating and ample space to regulate relationships, and much lower ward social density (Table 1). In New wards 71% of beds were in single rooms with private toilet and shower; Old had 50% single rooms but only 12% of patients had a private bathroom. Control had only 17% single rooms and all patients shared toilets and showers (Fig. 2). To achieve the same low social density as New at 100% bed occupancy (0.40 patient per room), bed occupancy would have to plummet to 52% in Old and 37% in Control. Although the number of patients per room differed widely among the hospitals, the ward group sizes were comparable (Old = 16 patients per ward, New = 14, Control = 12). Research on other types of settings suggests that large differences in group size can influence crowding stress (Baum & Davis, 1980).

New was also better than Old and Control in having communal spaces with features considered to reduce crowding. New wards had a large central communal space with several sub-areas that provided choices of movable seating (Fig. 3). Each sub-area was sufficiently separated and architecturally defined to enable a patient to avoid another person or group by moving to a different seating area (Figs. 3 and 6). (Each architecturally defined sub-area in the central area was counted as a communal room in calculating social density.) Seating in communal areas in Old wards was fixed or heavy; Control had a mix of movable and fixed furniture in shared spaces. Table 2 shows that space per patient was relatively abundant in seating and activity rooms in Old and New compared to the restricted amount in Control; both Old and New had about 2.5 times as much as Control (Table 2). The model implies that in Control wards the limited space in shared seating and activity areas would foster personal space intrusions, crowding stress, and aggressive incidents.

Fig. 2. A four-bed patient room in Control hospital. All toilets and showers were shared.

Fig. 3. Portion of a communal central area of a ward in New hospital showing groupings of movable and semi-movable seating. Half-wall partitions of break resistant glass enable staff moving in the central area to observe bedroom doors.

Regarding design to reduce environmental stress (noise reduction, features that foster control in patient rooms), New wards had sound-absorbing environmental surfaces to reduce noise, and bedrooms had design features for patient control such as a window that could be partly opened and controllable lighting. Old wards lacked sound-absorbing environmental surfaces and bedrooms had no design features to enable patient control. Control wards also lacked sound-absorbing surfaces to reduce noise, and the high proportion of multi-bed rooms (83%) and shared bathrooms (100%) worsened exposure to uncontrollable noise (Ulrich et al., 2008). Control had no design features to enable patient control in bedrooms.

Regarding stress reduction via positive distraction, New wards were superior to those in Old and Control in having gardens accessible to patients, window views throughout that overlooked gardens or other nature, and design features for increased daylight such as light wells, large windows, and atriums (Fig. 4). Each New ward had an unlocked door in a communal area that opened directly to a secure courtyard garden with seating choices and prominent vegetation including flowers (Fig. 5). Patients could easily access the garden without staff escort, and staff could observe the garden from the ward interior. Clinical staff reported informally to the investigators that patients heavily used the ward gardens in New in all seasons. (The garden was counted as a room in calculating ward social density.)

Old and Control wards had no gardens and no design features to

[3] Source of "more than 90% of the staff in New (2007) had previously worked in Old" was personal communication from the individual who was hospital director at the time.

[4] According to the Swedish Compulsory Psychiatric Care Act, compulsory care patients are those suffering from an acute mental disturbance that poses an immediate danger to their own life or health and/or the safety or health of others, and necessitates inpatient care at a psychiatric clinic having qualified staff available at all times. Patients can be committed on an involuntary basis if they refuse care or are unable to make a decision concerning care.

Table 2
Comparison of spatial density (ward space per patient) in Old, New, and Control hospitals.

Ward space per patient	Old hospital	New hospital	Control hospital
Patient group size	16	14	12
Total ward space per patient at 100% occupancy (excluding staff work areas)	37.7 m^2 (405.8 ft^2)	36.9 m^2 (397.2 ft^2)	20.3 m^2 (218.5 ft^2)
Space per patient in bedrooms and bathrooms	15.5 m^2 (166.8 ft^2)	16.5 m^2 (177.6 ft^2)	10.7 m^2 (115.2 ft^2)
bedrooms only	11.4 m^2 (122.7 ft^2)	13.5 m^2 (145.3 ft^2)	9.2 m^2 (99.0 ft^2)
bathrooms only	4.1 m^2 (44.1 ft^2)	3.0 m^2 (32.3 ft^2)	1.5 m^2 (16.1 ft^2)
Space per patient in shared areas (excluding staff work areas)	22.2 m^2 (239.0 ft^2)	20.5 m^2 (220.7 ft^2)	9.6 m^2 (103.3. ft^2)
corridors	10.1 m^2 (108.7 ft^2)	6.9 m^2 (74.3 ft^2)	4.7 m^2 (50.6 ft^2)
communal seating and activity areas	12.1 m^2 (130.2 ft^2)	13.6 m^2 (146.4 ft^2)	4.9 m^2 (52.7 ft^2)

Fig. 4. Atrium in a ward central area in New hospital. Wards in Old and Control hospitals had no atriums or light wells.

Fig. 5. Portion of a ward courtyard garden in New hospital. Wards in Old and Control hospitals had no gardens.

increase daylight such as an atrium or light well. Some window views in Old wards displayed nature while others overlooked built environments. Windows in Control overlooked built environments, not nature. All three hospitals had a mix of nature and abstract art images.

Concerning design for observation, wards in New had a floor plan that fostered good visibility by arranging patient rooms around a large central area (Fig. 6). Staff moving in the central area could observe all seating rooms, activity spaces, and bedroom doors (the last through glazed partitions as shown in Figs. 3 and 6). In contrast to the central area floor layout in New, Old and Control wards were dominated by double-loaded corridors that enabled staff observation from a central hallway of bedroom doors and doors of shared toilets and showers, but prevented visibility over communal rooms for seating and activities (Figs. 7–10).

5.3. Comparison of spatial density in old, new, and control hospitals

Table 2 compares ward spatial density (space per patient) at 100% designed bed occupancy in Old, New, and Control hospitals. In addition to listing the total ward space per patient, Table 2 provides a detailed break down of space per patient according to the four types of ward areas identified in the social density section (4.1.3): bedrooms, bathrooms, corridors, and seating/activity spaces. Total ward space per patient was slightly higher in Old (2%) than New; both Old and New provided markedly more total space per patient than Control.

The conceptual model considers corridors to have negative attributes that foster aggressive behavior and does not count the spaces as rooms in calculating ward social density (4.1.3). Corridor-dominated ward layouts also obstruct surveillance of communal seating and activity spaces that emanate from the corridors. Table 2 reveals that the two hospitals with corridor-based floor layouts (Old and Control), allocate a larger proportion of shared ward space (excluding bedrooms and bathrooms) to corridors than does the central area layout of New. Corridors in Old and Control consumed, respectively, 45% and 49% of total space in shared areas (corridors + seating and activity rooms), leaving 55% and 51% of space for seating areas and activity rooms. The central area design of New allocated a smaller proportion (34%) of total shared space to corridors, leaving a higher proportion (66%) for seating and activity rooms, or for other room types the model considers favorable for reducing crowding, such as single bedrooms with bathrooms.

5.44. Measures and analysis

Data for compulsory injections and physical restraints were obtained retrospectively for compulsory care patients in Old and Control hospitals for 2005, and New and Control for 2007. No data from 2006 were included because Old hospital was being phased out and patients and staff were being relocated to New. Unfortunately, data for the number of physical restraints in the Control hospital were incomplete.

Precise data were not available for the number of compulsory care patients annually in each hospital. However, it was deemed possible to make reasonably accurate estimates based on a variety of available quarterly information, for example, the number of compulsory care inpatients on the last day of each quarter, the number of inpatient treatment days for compulsory care patients, the proportion of compulsory versus non-compulsory care patients, and the total number of patients admitted to each hospital. The information was sufficient to

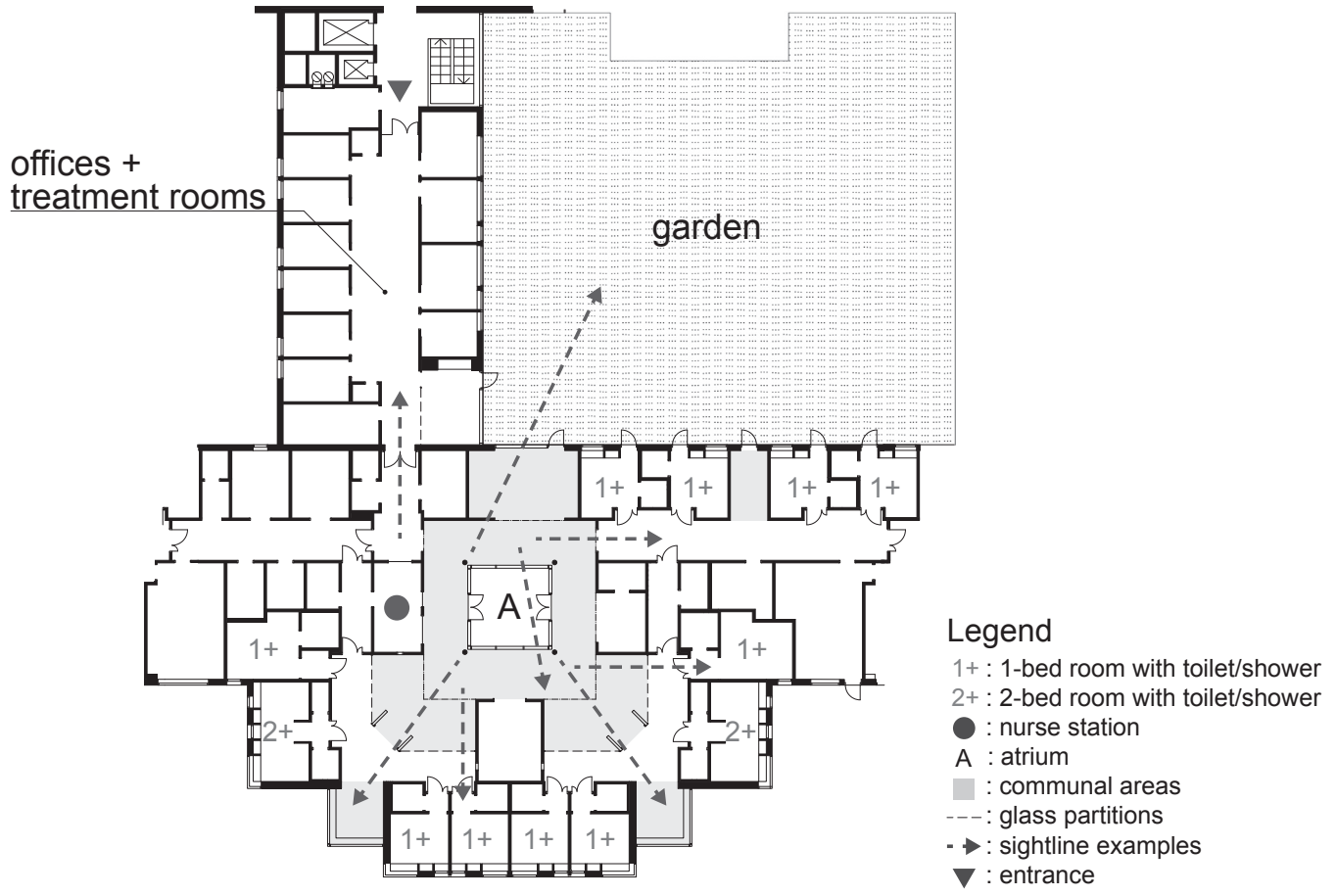

Fig. 6. One ward in New hospital. The floor layout arranges most patient rooms around a central area with an atrium. Staff moving within the central area can observe bedroom doors and communal spaces. New and Old hospitals were similar in total ward space per patient (spatial density) (Table 2) despite having very different floor layouts (central area versus corridor-dominated). Ward group size at 100% occupancy = 14 patients. Scale 1:500.

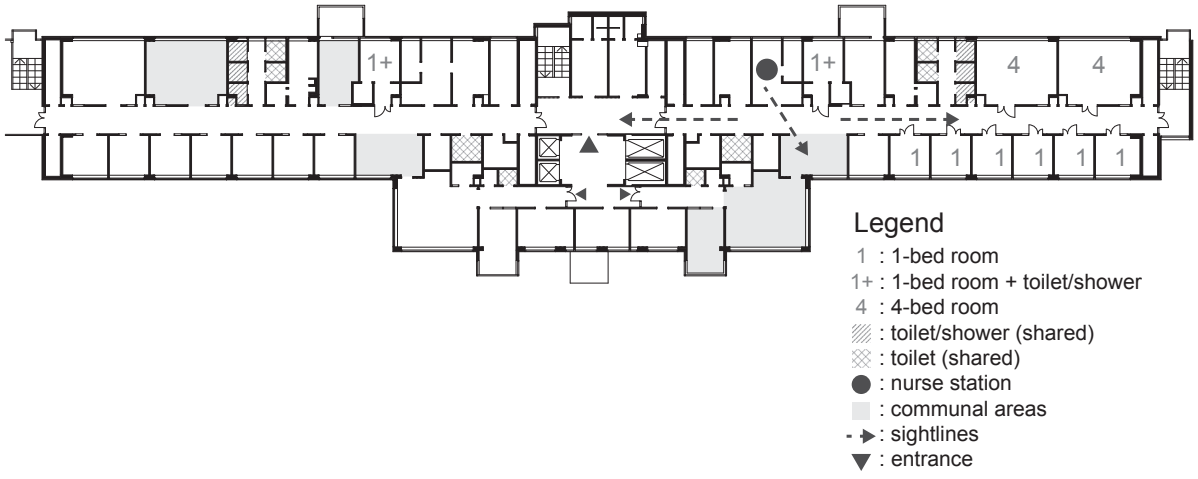

Fig. 7. One ward in Old hospital. The floor layout is corridor-based, enabling observation of bedroom doors and doors of most shared toilets and showers but not most seating areas and activity rooms. Ward group size at 100% occupancy = 16 patients. Scale 1:500.

prevent double-counting patients who stayed from one quarter to another. A clinician and former department head with experience in all three hospitals provided estimates of the annual compulsory care patient numbers. The estimates were considered accurate within ± 15 patients (Table 3).

In order to assess whether New hospital improved outcomes, multivariable logistic regression models were used to predict the proportions of patients who received injections (defined as the number receiving an injection divided by the estimated number of compulsory care patients) or who received physical restraints (defined similarly). Predictors were the year (either 2005 or 2007), the location (New or Old hospital vs. Control hospital), and the interaction between these binary terms. If the interaction term was significant, this indicated that the change from Old to New hospital was significantly different from

Fig. 8. Portion of a ward in Old hospital showing the corridor-dominated floor layout. The corridor-based design obstructs observation of seating and activity rooms accessed from the corridor. The photo was taken in 2010 after refurbishment for other types of patients. The hospital was subsequently demolished.

Fig. 10. Portion of a ward in Control hospital showing the corridor-based floor layout that prevented observation from a central point or seating and activity spaces accessed from the corridor.

any change that would be expected solely based on year. As a secondary analysis, designed to be more conservative in the face of uncertainty regarding the precise number of patients, a chi-squared test was performed to determine whether the proportions decreased from the Old to the New hospitals, but using the upper limit of the estimated number of patients for Old hospital (hence reducing the proportion), and the lower limit of the estimated patients for New (hence increasing the proportion).

6. Results

6.1. Injections (chemical restraints)

Multivariable logistic regression indicated that the proportion of patients receiving injections (the number receiving an injection divided by the estimated total number of compulsory care patients) did not significantly differ between the Old (20.2%) and Control (19.4%) hospitals in 2005 ($p = 0.780$) (Table 3). The analysis also indicated, consistent with a prediction based on the model, that in Control hospital the proportion of patients receiving injections did not decrease between 2005 and 2007 (Table 3). To the contrary, the proportion receiving injections somewhat increased from 19.4% to 24.3% in Control ($p = 0.132$).

It is noteworthy that the interaction term for the predictor variables of year (2005 or 2007) and location (New or Old hospital vs. Control) was significant ($p = 0.0027$). This indicates, consistent with the main prediction, that there was a significant reduction in the proportion of compulsory care patients receiving injections from 2005 in the Old hospital (99 out of 490 = 20.2%) to 2007 in the New hospital (63 out of 470 = 13.4%), even after adjusting for any difference between the years in the wider population (Table 3).

In the more conservative secondary analysis designed to minimize the difference in proportions, the proportion of patients receiving injections was 99 out of 505 (19.6%) in the Old hospital in 2005, and decreased to 63 out of 455 patients (13.8%) in the New hospital in 2007, with $p < 0.001$ from a chi-squared test. Therefore even if the number of compulsory care patients was inaccurate by the maximum plausible amount (± 15) (Table 3), the difference between the Old and New hospitals would still be robustly significant.

The number of injections for each individual was not available, and so a formal statistical comparison could not be performed. However, it

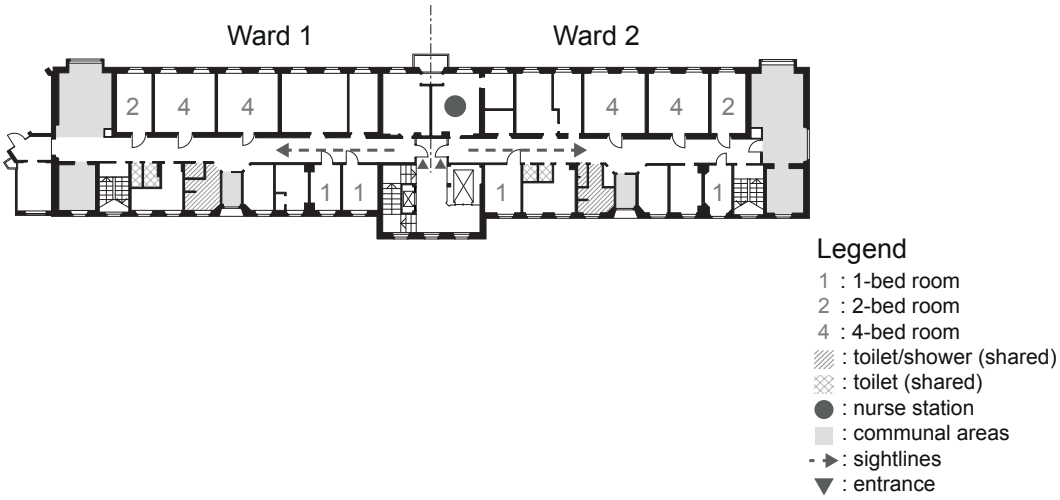

Fig. 9. Two wards in Control hospital. The floor layouts are corridor-based, enabling observation of bedroom doors and doors of shared toilets and showers but obstructing visibility of seating areas and activity rooms. Group size of one ward at 100% occupancy = 12 patients. Scale 1:500.

Table 3
Data for compulsory injections and physical restraints in Old, New, and Control hospitals.

Data for injections and physical restraints	Old hospital	New hospital	Control hospital	
Year	2005	2007	2005	2007
Estimated total number compulsory care patients	490 ± 15	470 ± 15	345 ± 15	300 ± 15
Number patients receiving injections	99 (20.2%)	63 (13.4%)	67 (19.4%)	73 (24.3%)
Number injections	189 (1.91/patient[a])	115 (1.83/patient)	134 (2.00/patient)	174 (2.38/patient)
Number patients receiving physical restraints	56 (11.4%)	60 (12.7%)	70 (20.3%)	66 (22.0%)
Number physical restraints	250 (4.46/patient[b])	135 (2.25/patient)	n/a	n/a

[a] Average number of injections per patient among those who received at least one.
[b] Average number of physical restraints per patient among those who received at least one.

is notable that the average number of compulsory injections among those patients who received at least one during their hospital stay decreased marginally (by 4%) following the move from Old hospital to New hospital (from 1.91 in the Old hospital in 2005 to 1.83 in New in 2007), while in the Control hospital the average number of injections for patients who received at least one increased by 19% during the same period (from 2.00 in 2005 to 2.38 in 2007).

6.2. Physical restraints

The proportion of all compulsory care patients receiving physical restraints (Table 3) was significantly lower in the Old hospital (11.4%) in 2005 than in the Control hospital in 2005 (20.3%) ($p < 0.001$). Consistent with the hypotheses, there were no differences in the multivariable logistic model in the Control hospital between 2005 and 2007 ($p = 0.595$), indicating that the proportion of patients receiving restraints did not change. However, the interaction was not significant, indicating that the change from the Old to New hospital did not reduce the proportion receiving restraints after accounting for any overall trend between the years. Nonetheless it is notable that the average number of physical restraints for patients who received at least one did decrease by 50% following the move from Old to New hospital (from 4.46 in the Old hospital in 2005 to 2.25 in the New hospital in 2007) (Table 3). Again, the data for individual patients were not available and so no formal statistical test is possible for this comparison. However, quarterly clinical data indicated that restraint incidence in New for compulsory care patients was consistently lower during 2007 compared to the incidence in Old during 2005, suggesting that this difference was not driven by a small number of outliers. (Patients who stayed from one quarter to another were not double-counted.)

7. Discussion

There has been an absence of theory for designing the physical environment of psychiatric facilities to reduce aggression behavior, and little research has examined the possible influence of ward design features on aggression and other outcomes. The first part of the article describes a conceptual model for designing wards that proposes stress fosters and triggers aggression. The model contends that architecture can help reduce aggression if wards have been designed with several environmental features that diminish stress.

The second part of the article provides an empirical appraisal of the conceptual model by comparing data for two reportable clinical markers of aggressive behavior – compulsory injections and physical restraints – in three Swedish psychiatric hospitals that varied widely with respect to design features in the model but were similar in non-environmental factors known to influence aggression. Based on the model it was hypothesized that use of compulsory injections and physical restraints would be lowest in a newer hospital (New) having wards with nine of the ten design features identified as likely to reduce stress and aggression, compared with an older hospital (Old) that New replaced, and with another control hospital (Control). Wards in Old and Control had only one of the stress reducing features in the design model, Consistent with the prediction based on the model, the data show that the proportion of patients requiring injections was significantly reduced in the New hospital after the move from Old hospital ($p < 0.0027$). Also as hypothesized, this improvement was not present in data for the Control hospital, where the proportion increased from 19.4% to 24.3%. The findings indicated that the significant reduction in injection prevalence in New remained after accounting for change in the wider population (including Control) over the same time period. There was no significant change in the proportion of patients requiring physical restraints. However, it is notable that the average number of physical restraints (for patients who received at least one) decreased by 50% following the move from Old to New hospital.

The limited amount of previous research on the influence of the physical environment of psychiatric facilities on outcomes has been criticized for failing to control for organizational and other non-environmental factors (Papoulias et al., 2014). The similarity in the hospitals with respect to non-environmental factors (section 5.1) and the repeated-measures study design helped to minimize non-environmental variables known to influence aggressive behavior. No organizational or treatment protocol changes occurred in the hospitals during the period of the study. An important added strength of the research design is the inclusion of data from a Control hospital that did not undergo architectural change during the period of the study (Campbell & Stanley, 1963).

Limitations of the research include the retrospective design and unavailability of data for the number of injections and physical restraints for individual patients. However, the results concerning the proportion of patients requiring injections are robust throughout the margin of error of the patient number estimates. The reductions in markers of aggressive behavior shown in New hospital could be caused by reduced stress in patients or staff, or as the model proposes, in both patients and staff. Although the research does not distinguish between these possibilities, any of them would be desirable. Future studies could shed light on this issue by measuring the influences of changes in environmental features on stress in both patients and staff.

Data were obtained for three psychiatric hospitals in Sweden, which raises the issue of the generalizability of the findings to other countries. The prevalence of aggressive behavior and violence by acute patients (excluding forensic patients) admitted to psychiatric facilities appears to be moderately similar across Sweden, the United Kingdom, the United States, and Australia (Bowers et al., 2011). Estimates of violence rates for patients with psychotic disorders vary little across Sweden, the United Kingdom, and the United States (Merikangas, Jin, He, Kessler, Lee, Sampson, Viana et al., 2011; Sariasian et al., 2016). Sariasian and colleagues concluded that for key violence outcomes in persons with psychotic disorders, Sweden is similar to Western Europe and the United States (Sariasian et al., 2016).

The conceptual model described in this research may be the first for designing healthcare facilities to include and explicitly define the

concept of social density for psychiatric wards. Consistent with crowding research on other types of environments (such as apartments or prisons), it proposes that social density (defined as the number of patients per room) is more reliably linked to stress and aggression than space per patient. Nonetheless, the model advocates providing ample space per patient in seating and activity rooms to support the greater personal space distances that many psychiatric patients presumably need in shared areas. An important implication of the conceptual model for patient/staff safety and hospital management is that increases in occupancy rates are expected to worsen crowding stress and aggressive behavior in wards having high social density features such as multi-bed rooms and shared toilets and showers. However, rising occupancy may be only weakly associated with aggressive behavior in hospitals having well-designed wards with low social density and several other stress-reducing environmental features identified in the model (such as a garden accessible to patients and design for good visibility). The failure of research in psychiatry to explicitly consider and report social density and several other aspects of the physical environment that influence stress has made it difficult for researchers in other fields to interpret the conflicting findings on ward occupancy rates and aggression.

It is noteworthy that New and Old hospitals were similar in space per patient (Table 2), occupancy rates (Table 1), and ward group size (14 and 16 patients respectively), but levels of aggressive behavior were lower in New. New wards were superior to those in Old in having lower social density (0.40 and 0.76 respectively) and several other stress-reducing features in the model not present in Old (Table 1). The findings suggest that allocating spending and designing psychiatric facilities to include the environmental features in the model may have overall greater positive impact than increasing total space per patient.

The proportion of patients receiving injections was highest in the Control hospital, which had wards with the smallest group size (12 patients) but the highest social density (1.09), and only one of the environmental features in the model identified as likely to reduce stress and aggression. Control also had the least space per patient (highest spatial density) among the study hospitals (Table 2). The model implies that the restricted space per patient in seating and activity areas in Control wards may have contributed to crowding stress and aggressive behavior.

The model considers corridors in psychiatric wards to have negative attributes that foster aggressive behavior and thus excludes the spaces in calculating ward social density (4.1.3). Previous research has shown that corridors are the location of many aggressive incidents (Lanza et al., 1993), and corridor-dominated ward layouts often obstruct observation of spaces emanating from corridors (Figs. 8 and 10) (Wener, 2012). Ward space measurements in the study hospitals showed that corridor-dominated floor layouts (Old and Control) allocated a larger proportion of space to corridors than the central area design of New (Table 2). Central area layouts, compared to corridor-based floor plans, may afford designers more flexibility in allocating ward space to room types the model considers favorable for reducing crowding, such as single bedrooms with bathrooms. Further, floor layouts organized around central areas can facilitate more comprehensive observation of wards than corridor-based designs, and more effectively support supervision models calling for staff to be outside workstations unobtrusively monitoring patients and interacting with them on an individualized basis.

7.1. Research needs and directions

It is likely that certain environmental factors in the model are more important than others for lessening stress and aggression, and some features may interact. Implementing some of the design features, such as single rooms with private toilets and showers, requires costly renovation or new construction, creating practical obstacles to carrying out prospective randomized studies. (There could also be ethical objections to assigning patients randomly to single rooms versus multi-bed rooms, such as increased infection acquisition risk for those assigned multi-bed rooms and shared toilets.) However, other environmental interventions in the model are relatively inexpensive, do not require disruptive construction, and can be provided in nearly any psychiatric or other healthcare facility. Examples include movable furniture, nature pictures, and sound-absorbing ceiling tiles and wall panels. In future research it would be possible to carry out prospective controlled studies by systematically varying the absence/presence in wards of certain stress mitigating features such as sound-absorbing surfaces. This approach has been used successfully in research on general hospitals to clarify the effects of specific design interventions on patient and staff outcomes (Blomkvist et al., 2005; Hagerman et al., 2005).

It would be desirable in future studies to include measures of staff outcomes such as work stress, satisfaction, and perceived security. The conceptual model posits that implementing the design features will positively influence staff outcomes in addition to diminishing patient stress and aggressive behavior. Research on other types of locked treatment facilities suggests that reduction of aggressive behavior is associated with decreased staff stress (Wells, Minor, Angel, Matz, & Amato, 2009).

It is possible that as research on psychiatric environments progresses additional design features will be identified that meet the criteria for inclusion in the model (section 3). One design characteristic not included in the model, non-institutional or home-like decor, has been widely recommended as best practice for psychiatric hospitals, somatic hospitals, and Alzheimer's units (Karlin & Zeiss, 2006; Shepley et al., 2016). However, the concept remains vaguely defined and evidence concerning influences of non-institutional design on aggression is sparse and conflicting (Vaaler, Morken, & Linaker, 2005).

The conceptual model and empirical findings together suggest that providing improved psychiatric buildings with design informed by theory and research can help reduce the serious patient and staff safety threat posed by aggressive behavior. The research implies the need for studies on a variety of other environments across the wider healthcare system. Aggressive behavior and physical violence in healthcare are by no means limited to psychiatric wards; they are also common and serious problems in emergency rooms and other somatic hospital departments (Gates, Ross, & McQueen, 2005; Ulrich, 2013, p. 12). Based on concepts from the model (Fig. 1) it seems reasonable to predict that stress and violence could be worsened if an emergency department waiting room, for example, has fixed rows of seats, a loud television whose channel cannot be changed, noisy drink and vending machines, poor acoustics from a lack of sound-absorbing surfaces, and no calming distractions such as nature pictures or a garden (Ulrich, 2013, p. 12). Fortunately, the research discussed in this article shows there is growing knowledge about design approaches that can effectively reduce stress in healthcare settings, potentially lessen aggressive behavior, and perhaps lower the cost of care as well (Ulrich et al., 2008).

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Disclosure of conflicts

RSU, LB, and SKG have no conflicts. SL was a member of the architecture team that designed New hospital.

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