

Is greenery associated with mental health among residents of aged care facilities?

A systematic search and narrative review

Alison Carver^a, Alanna Lorenzon^a, Jenny Veitch^b, Ashley Macleod^c, Takemi Sugiyama^{a,d}

^a *Mary MacKillop Institute for Health Research, Australian Catholic University, Melbourne, Victoria, Australia*

^b *Institute for Physical Activity and Nutrition (IPAN), School of Exercise and Nutrition Sciences, Deakin University, Geelong, Australia*

^c *Faculty of Health, Arts and Design, Swinburne University of Technology, Hawthorn, Victoria, Australia*

^d *Centre for Urban Transitions, Swinburne University of Technology, Hawthorn, Victoria, Australia*

Corresponding author:

Dr Alison Carver
Research, Fellow
Mary MacKillop Institute for Health Research
Australian Catholic University
215 Spring St, Melbourne, VIC 3000, Australia
email: Alison.Carver@acu.edu.au
Tel: +61 3 9230 8334

Acknowledgement

JV is supported by an Australian National Heart Foundation Future Leader Fellowship (ID 101928).

Citation:

Carver A, Lorenzon A, Veitch J, Macleod A, Sugiyama T. (In press). Is greenery associated with mental health among residents of aged care facilities? A systematic search and narrative review. *Aging and Mental Health* (accepted on 22 August 2018).

Abstract

Objectives: Older adults living in residential aged care facilities (RACFs) may be vulnerable to mental health issues. Evidence suggests greenery is beneficial for adults' mental health in community settings. This review aims to summarise evidence of associations between greenery in RACFs and residents' mental health.

Method: Six databases were searched with three sets of terms related to: (1) exposure (e.g., garden, green); (2) outcome (e.g., mental health, well-being); and (3) setting (e.g., aged care, nursing home). The inclusion criteria were peer-reviewed journal articles published in English up to 2017, reporting quantitative/qualitative associations between greenery and mental health in RACFs.

Results: Of the nine articles identified, seven reported positive associations between greenery (in particular, garden use) at RACFs and some aspect of residents' mental well-being (e.g., quality of life); however, four out of seven studies used observations and perceptions of staff and relatives. One study examined depression and reported reduction in depression following garden use, while one examined physiological indicators of stress (blood pressure, heart rate) and found no association with garden use. Seven studies examined garden use and four examined the presence of greenery (two examined both exposures).

Conclusion: Exposure to greenery and use of greenspace in RACFs show promise for promoting mental health. However, the findings relied mainly on non-validated measures of mental health. More robust evidence based on valid and reliable mental health measures is needed. Future studies also need to examine the effect of visual exposure to greenery and the effect of greenery on stress reduction.

KEYWORDS: residential care; greenspace; garden; mental well-being; depression

Introduction

Mental health conditions, which include depressive and anxiety disorders, are of major public health concern worldwide and contribute to 13% of the Global Burden of Disease (GBD) (WHO, 2013). Sufferers of depressive disorders may experience sadness, poor self-esteem, lack of pleasure, fatigue as well as disruption to sleep and appetite (WHO, 2017). Prolonged and frequent episodes of depression can have debilitating effects on one's employment, education or daily functioning (WHO, 2017). Anxiety disorders are characterized by persistent feelings of anxiety and excessive worry that influence an individual's capacity to carry out daily activities (BeyondBlue, 2018; WHO, 2017). The number of people with depression worldwide (322 million) is reported to have increased by 18% from 2005-15, while the number of people with anxiety disorders (264 million) has increased by 15% over the same period (WHO, 2017).

Mental health issues are particularly salient in residential aged care facilities (RACFs). An Australian study reported that 32% of residents of RACFs had depression compared with 14% of community-dwelling older adults (Anstey, von Sanden, Sargent-Cox, & Luszcz, 2007), whilst data from the Cognitive Function and Ageing Studies in England reported rates of depression among older adults in RACFs and the general community to be 17% and 8% respectively in 1989, and 14% and 6% respectively in 2009 (Matthews et al., 2016). Transition to a RACF can be particularly stressful, and has been linked to increased depressive symptoms. It has been reported in the US that 33% of newly-admitted residents had depression, and a further 22% developed depression within the first year after admission (Sury, Burns, & Brodaty, 2013).

Despite the high prevalence and increasing severity of mental illness in RACFs, few facilities

have adequate access to mental health treatment options, and staff are often not trained with the required skills to deal with these mental health issues (Palinkas et al., 2007). There is also a reliance on psychotropic medications to manage symptoms of mental illness among residents (Lindsey, 2009). In addition, older adults are often unlikely to discuss mental health issues or seek help due to many reasons such as non-recognition of symptoms (Bryant, 2010), their reluctance to complain (Bryant, 2010; Gonçalves, Albuquerque, Byrne, & Pachana, 2009), and the perceived stigma attached to mental illness (Conner et al., 2010). It is thus important to develop non-clinical approaches to help mitigate mental health problems in RACFs. One possible avenue is the design of the physical environment of RACFs, which has been increasingly recognised as having an impact on residents' well-being (Fleming, Goodenough, Low, Chenoweth, & Brodaty, 2016).

One potential design factor in RACFs that may confer mental health benefits is greenery which, in this setting, may comprise indoor plants, vegetation in a garden/courtyard, and a view of natural elements outside RACFs. An emerging body of research suggests that exposure to various forms of natural green elements (e.g., trees; vegetation; plants) and greenspace (space that contains green elements, e.g., parks; gardens; public open space (POS); sports fields; bushland and woodland) is beneficial to mental health among community-dwelling adults (Sturm and Cohen, 2014; Ward Thompson, Aspinall, Roe, Robertson, & Miller, 2016). For example, the presence of or contact with greenspace in local neighbourhoods was associated with favourable mental health outcomes such as low levels of psychological distress (Sturm and Cohen, 2014) and low levels of stress (Hazer, Formica, Dieterlen, & Morley, 2018; Ward Thompson, et al., 2016) among adult residents. Viewing greenery is associated with physiological indicators of

being in a relaxed state (Tsunetsugu et al., 2013) and views of greenery have been shown to promote healing from surgery (Ulrich, 1984).

There are some plausible mechanisms that help to explain how exposure to greenery can influence mental health. There are two complimentary theories on greenery and mental health: stress-recovery theory (SRT) (Ulrich, 1983) and attention restoration theory (ART) (Kaplan, 1995). SRT posits that positive emotions invoked by spending time in natural settings can reduce physiological responses to stress (Ulrich, 1983). ART suggests that contact with nature may reduce attentional fatigue through a mechanism called attention restoration (Frumkin and Fox, 2011; Kaplan, 1995), which may allow individuals to ignore competing stimuli by focusing on the natural environment and greenery (Kaplan, 1995). SRT may be more applicable to residential aged-care settings, as residents may have to cope with stressors such as lack of independence and privacy, feelings of social isolation, noise, and institutional regulations (Choi, Ransom, & Wyllie, 2008).

Several literature reviews on greenery and mental health have been conducted previously, but they have focussed on the health benefits of urban greenspace (e.g., parks and nature reserves) for adults who reside in the general community (Gascon et al., 2015; Hassen, 2016; van den Berg et al., 2015). One of the reviews highlighted a lack of studies on particular subgroups or settings and consequent lack of context-specific evidence (van den Berg, et al., 2015). There is an earlier review summarizing the impact of RACF design factors on residents with dementia (Marquardt, Bueter, & Motzek, 2014), but it did not consider greenery. Addressing these gaps in the literature, this current review aims to summarise existing knowledge of whether the availability

and use of greenery in RACFs are associated with residents' mental health.

Methods

Search strategy

A systematic search using six databases (Academic Search Complete; Art & Architecture Source; CINAHL Complete; Environment Complete; MEDLINE Complete; PsycINFO) was undertaken in July 2017. There were three sets of search terms: (1) exposure (environment* OR foliage OR forest* OR garden* OR green* OR landscape OR lawn* OR natur* OR "open space*" OR park* OR plant* OR reserve OR POS OR tree* OR vegetation OR courtyard OR horticult* OR therapeutic); (2) outcome ("mental health" OR "mental illness" OR well-being OR "well being" OR wellbeing OR stress* OR depress* OR anxiety OR psycholog* OR distress OR disorder OR mood OR restorat* OR ("quality of life" OR "QoL")); and (3) the setting ("aged-care" OR "aged care" OR "nursing home*" OR "residential facilit*" OR "care home*" OR "care facilit*" OR "special care unit*" OR "long-term care" OR "long term care").

Inclusion/exclusion criteria

The inclusion criteria were: written in English language; published in a peer-reviewed journal; reporting quantitative or qualitative associations between greenery and mental health in RACFs. The exclusion criteria were studies examining residents' cognitive issues or behavioural problems (e.g., agitation); studies conducted in non-RACF settings (e.g., retirement villages); and commentary/editorial articles. The initial search was undertaken by the first author (AC). All identified titles and abstracts were screened independently by two authors (AC, AL). The full

texts of articles potentially eligible for inclusion were reviewed by three authors (AC, AL and JV). Discrepancies were resolved by the last author (TS). In light of the limited research on this topic and the difficulty of assessing mental health among RACF residents we included studies where staff or family members' perceptions about the benefits of greenery were examined. We also included studies examining stress as an outcome, given that accumulation of stressful events can lead to mental health problems (Kraaij, Arensman, & Spinhoven, 2002; Vink, Aartsen, & Schoevers, 2008). The following data were extracted from the studies identified: country in which study was conducted; participant characteristics; study design; outcome measures; exposure measures; analytical approach; and findings.

Results

The initial search produced 1,346 articles. After a series of screening, nine articles met the inclusion criteria (see. Figure 1 for screening process). A narrative review, rather than a systematic review, was conducted due to the small number of screened studies, which varied in design and used non-validated measures and descriptive analyses (described below). It was thus considered that formal assessment of the quality of evidence would not provide useful information at this stage.

Supplementary Table 1 details the nine articles included. Three studies were based in Australia (Cioffi, Fleming, Wilkes, Sinfield, & Le Miere, 2007; Cox, Burns, & Savage, 2004; Edwards, McDonnell, & Merl, 2013), three in the US (Hernandez, 2007; Kearney and Winterbottom, 2005; Rodiek, 2006) and three in Europe (Artmann et al., 2017; Ottosson and Grahn, 2005; Rappe and Topo, 2007). One of the European studies was conducted across six countries

(Artmann, et al., 2017). Four were quasi-experimental studies (Cioffi, et al., 2007; Cox, et al., 2004; Edwards, et al., 2013; Ottosson and Grahn, 2005) and five were observational studies (Artmann, et al., 2017; Hernandez, 2007; Kearney and Winterbottom, 2005; Rappe and Topo, 2007; Rodiek, 2006).

Mental health measures (outcome)

The mental health outcome measures are summarised in Table 1. Most studies (n=8) explored some aspect of mental well-being (e.g., quality of life), two examined stress and one examined depression. Of the eight studies that examined well-being, four reported staff and/or family members' perceptions of residents' well-being (Artmann, et al., 2017; Cioffi, et al., 2007; Hernandez, 2007; Rappe and Topo, 2007) and two described residents' self-reported well-being (Kearney and Winterbottom, 2005; Rodiek, 2006). Two studies used validated measures related to mental well-being for those with Alzheimer's disease and dementia, respectively: one of these (Cox, et al., 2004) used the Affect Rating Scale (ARS) (Lawton, Haitsma, & Klapper, 1996), while the other (Edwards, et al., 2013) used the Dementia Quality of life Instrument (DEMQOL, DEMQOLProxy) (Brod, Stewart, Sands, & Walton, 1999). The ARS includes three categories of positive affect (pleasure, interest and contentment) and three categories of negative affect (anger, anxiety/fear and sadness) as visible signals of well-being (Cox, et al., 2004). The DEMQOL system consists of two interviewer-administered instruments to assess quality of life among those with dementia: DEMQOL for those with mild-moderate dementia and DEMQOL Proxy for completion by main carers of those with moderate-severe dementia (Edwards, et al., 2013).

Of the two studies that measured stress; one (Hernandez, 2007) reported staff perceptions of

residents' stress and another (Ottooson and Grahn, 2005) used physiological measures (systolic and diastolic blood pressure; heart rate) as objective indicators of stress. Depression was assessed in one study (Edwards, et al., 2013), using the validated Cornell Scale for Depression in Dementia (Alexopoulos, Abrams, Young, & Shamoian, 1988).

(INSERT TABLE 1 ABOUT HERE)

Greenery measures (exposure)

Greenery measures are summarised in Table 2. Most (n=7) studies examined garden use within the RACF, while four examined the presence of a garden as an exposure to greenery. Four studies assessed staff or family members' perceptions of how the use of greenspace was beneficial to residents' mental health; three of these also examined their perceptions of the presence of a garden as a greenery exposure. One study in Finland focussed specifically on plants rather than a garden as the greenery exposure (Rappe and Topo, 2007). Frequency of garden use was reported for descriptive purposes only (i.e. not analysed as a predictor of mental health outcome) by three studies (Artmann, et al., 2017; Edwards, et al., 2013; Kearney and Winterbottom, 2005), while two quasi-experimental studies included garden visits of specific duration and measured their impact on mental health measures (Cox, et al., 2004; Ottooson and Grahn, 2005). No study examined the quantity or quality of greenery.

(INSERT TABLE 2 ABOUT HERE)

Associations between greenery and mental health

A summary of associations between greenery (presence and use) and mental health is presented in Table 3. The majority of studies reported positive associations between use and presence of gardens at RACFs and the mental well-being of residents. However, as described previously, few studies used validated measures of mental health. If we exclude the studies using non-validated outcome measures, the review shows mixed evidence on the mental health benefits of greenery. In the following, we have summarised the findings according to study design.

(INSERT TABLE 3 ABOUT HERE)

Quasi-experimental studies

An Australian study (Cioffi, et al., 2007) examined the effects of relocation from a traditional style dementia care facility (circa 1950) to a newly-constructed special care unit designed specifically for dementia patients. Previously, residents had limited access to a garden with uneven paving stones. At the new special care unit they were able to freely access several garden areas that included wandering paths, a small pavilion and an imitation bus stop (Cioffi, et al., 2007). Focus groups (n=5) with staff and family members found that this extra outdoor greenspace, which was under discrete surveillance by staff, improved the autonomy of residents thus contributing to their overall quality of life (Cioffi, et al., 2007).

Another quasi-experimental study in Australia (Cox, et al., 2004) examined the impact of being in a garden compared to being in a living room within the RACF, using the Affect Rating Scale (ARS), which enables an observer to assess a subject's emotions as an indicator of well-being. The garden at that facility attracted birdlife and included elevated planter boxes containing

flowers and foliage with a variety of scents, colours and tactile properties. There were no significant differences in rates of pleasure experienced by residents between the garden (43%) and living room (46%), or in respective rates of interest (15% and 24%) or contentment (30% and 25%) in these environments (Cox, et al., 2004). The study found that the factor influencing participants' emotional response was the presence or non-presence of a caregiver, rather than the locations.

A further quasi-experimental study in Australia (Edwards, et al., 2013) evaluated the impact of installing a therapeutic, sensory wander garden on quality of life and depression among 10 residents. Comparing measurements three months before and three months after the garden was introduced, the mean quality of life score increased by 12.8% ($p < 0.001$) and the mean depression score decreased by 13.3% ($p = 0.02$) (Edwards, et al., 2013).

A study in Sweden (Ottosson and Grahn, 2005) measured residents' ($n=15$) blood pressure and heart rate as indicators of stress before and after a garden visit lasting one hour. Overall, there was no impact on these measures after visiting the garden. However, there were significant reductions in these variables after spending time in the garden among those who lacked tolerance of other residents, were not team-players in group activities and who required regular hospital care (Ottosson and Grahn, 2005).

Observational studies

An observational study (Rodiek, 2006) at 14 RACFs in the USA asked residents with appropriate levels of cognition and function ($n=211$) to venture outside unaided and to self-report using

surveys how they felt generally after spending time in outdoor areas (courtyards, paths and garden areas). Overall, their experiences were positive: 37% of residents reported feeling ‘much better’ and a further 37% reported feeling ‘slightly better’ after they spent time outdoors. The remainder felt the same (23%) or worse (3%) after being in the outdoor areas (Rodiek, 2006).

Two studies, both in the USA, conducted interviews with staff and family members (Hernandez, 2007) and with residents (Kearney and Winterbottom, 2005) to examine how use of garden or outdoor areas with greenery was associated with mental well-being. One of these (Hernandez, 2007) evaluated the role of gardens as a form of therapy for residents with dementia at two special care units. Staff (n=28) and family members (n=12) reported that garden use made residents happy while spending time outside improved mood and increased interest in indoor happenings/pursuits after being outdoors. Staff members also considered the garden to be important for residents as a setting for stress relief (Hernandez, 2007). The other study interviewed long-term residents (without Alzheimer’s disease, n=40) of three aged-care facilities (Kearney and Winterbottom, 2005). They found that residents valued accessible greenspace highly as a setting for interaction with nature and/or other people, where one could feel mentally and physically refreshed.

Two further observational studies used surveys to investigate perceptions of RACF staff regarding the mental well-being benefits of greenery or greenspace. One of these was a multi-centre study that involved 126 managers of aged-care facilities across six European countries (Artmann, et al., 2017). Having a useable garden was considered to be beneficial to residents’ mental well-being by providing a setting for social interaction, physical activity (strolling) and

therapeutic use in about two-thirds of the facilities. The other study asked staff (n=65) from one RACF in Finland to assess potential benefits from exposure to indoor and outdoor plants (Rappe and Topo, 2007). It was found that indoor and outdoor plants were considered to contribute to residents' well-being by providing sensory stimulation and a topic of conversation that prompted social interaction. Further, residents were perceived to experience positive feelings of self-worth and achievement through nurturing plants (Rappe and Topo, 2007).

Discussion

Overall the findings of this review suggest that exposure to greenery and use of greenspace in RACFs show promise in promoting positive mental health among residents. However, it is apparent from the low number of studies identified in this review and the use of non-validated mental health measures that this field of research is in its infancy. Whilst a few studies (Ottooson and Grahn, 2005) (Ottooson and Grahn, 2005; Rappe and Topo, 2007; Rodiek, 2006) included in this review cited Stress Reduction Theory (Ulrich, 1983) in their background sections, only one of these studies appeared to frame its research questions based on this theory (Ottooson and Grahn, 2005). Further research guided by a theoretical framework is needed to produce more robust evidence on the relationship between greenery and mental health in RACF settings.

Methods for measuring mental health outcomes in aged-care settings can vary depending on the cognitive state of the resident and the aspect of mental health being assessed (e.g. depression; anxiety; quality of life). There may be further difficulties due to limited language capability in eliciting views from residents of aged-care facilities on how the built environment may influence their mental health (Burton and Sheehan, 2010). Therefore, measuring mental health

consistently in RACFs, where residents' cognitive status may differ widely is challenging and this may impact the ability to compare results between studies. However, this area of research needs to move beyond the perceptions of staff/family members to accurately assess residents' mental health. There are several validated scales that have been used in aged-care settings to measure depression such as the Depression Anxiety and Stress Scale (DASS) (Lovibond and Lovibond, 1995) and the Cornell Scale for Depression in Dementia (Alexopoulos, et al., 1988), specifically for those with dementia. Similarly, stress, which can be a precursor of poor mental health, can be assessed using validated scales such as the DASS (Lovibond and Lovibond, 1995) and measured objectively using biomarkers such as heart rate, blood pressure (Ottosson and Grahn, 2005) and cortisol (Honold, Lakes, Beyer, & Meer, 2016; Olstad et al., 2016). This approach may be more suitable to some participants for whom a long interview can be burdensome.

Existing studies in this review examined the use and presence of greenery. No studies were identified that have measured the quantity or quality of greenery or have provided insights into how much or what type of greenery is needed to confer mental health benefits in RACFs. Future research needs to develop a method of measuring the quantity of greenery. One possibility is to capture greenery two-dimensionally (as a view from a certain point) via photography (Yang, Zhao, McBride, & Gong, 2009). Other possibilities include measurement of the volume of greenery based on aerial photos (Verma, Lamb, Reid, & Wilson, 2016) and identification of individual trees using Unmanned Aerial Vehicles (UAVs) or drones (Mohan et al., 2017). Auditing is a potential method to assess the quality of greenery. For example, the Community Park Audit Tool developed in the USA includes items to assess maintenance and aesthetics of

greenery and greenspace within public parks (Kaczynski, Wilhelm Stanis, & Besenyi, 2012) .

Collaboration with researchers with technical expertise (e.g., image recognition, remote sensing, and forest biometrics) may help develop a robust measure of greenery.

Our findings demonstrate that the presence of greenery within RACFs shows promise in conferring benefits for mental health. In the Introduction, we argued that stress reduction is a possible mechanism linking greenery and mental health. However, it cannot be deduced from these findings whether visual exposure to greenery (e.g., via a view from a window) or physical exposure (e.g., a garden visit) is more important. An earlier study suggests that a view of greenery has therapeutic effects (Ulrich, 1984). “Openness” of outdoor greenspace or greater levels of visual depth may provide a sense of relief for those who are confined to RACF’s indoor space (Tveit, Ode, & Fry, 2006). On the contrary, physical exposure to greenery, which can accompany exposure to fresh air and natural light, may be more relevant (Morita et al., 2007). Except for one study, which specifically discussed a view from window (Hernandez, 2007), none of the included studies distinguished between the visual and physical aspects of greenery. Further research is needed to better understand in what ways greenery confers mental health benefits in the context of RACFs.

Accessible greenspaces may promote mental health also by prompting social interaction in outdoor green areas among residents, staff, and family members. However, it may not be practical to expect that outdoor spaces at RACFs are always accessible, given that RACF staff members may not have capacity to accompany/supervise residents in outdoor spaces. It may be possible to resolve this in creative ways through design. As demonstrated by an Australian study

(Cioffi, et al., 2007), glass doors and large windows overlooking greenspace can provide opportunities for discrete surveillance by staff without impeding the independence of residents in the garden.

Studies identified in this review used descriptive or binary analyses in examining the relationships between greenery and mental health, which means that they did not consider potential confounders in their analyses. Various individual- and RACF-level factors can moderate/or and mediate the association between greenery and mental health. Potentially relevant individual-level factors include residents' functional independence, sleep quantity and quality, interaction with staff, and diversity of their daily activities (e.g., having guests, going out). Facility-level factors such as service delivery approach (e.g., traditional versus person-centred care) and other design characteristics (e.g., size, privacy/crowding, lighting, noise, access to outdoor space) may also be relevant. Future research needs to take these variables into account to accurately assess the relationships between greenery and residents' mental health in RACFs.

To progress this field of research, further studies with validated, reliable measures of mental health and greenery are required to examine their relationships in RACFs. It has been shown that greater exposure to greenery is associated with lower rates of depression particularly among older adults living in low-income neighbourhoods, compared with those in high-income neighbourhoods (Brown et al., 2018). Future research should explore whether the role of greenery differs among RACFs located in areas of varying socio-economic status. Studies with longitudinal observational design (examining how greenery at baseline is related to participants' mental health over time) or experimental design (examining the impact of additional greenery)

will inform RACF managers if greenery improves the mental health of residents. Studies investigating the quantity and quality of greenery are also needed to help practitioners make informed decisions about the design of greenery in RACFs. This will guide interventions that aim to improve mental health among this vulnerable population group that is predicted to increase as the broader population ages in coming years.

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Table 1. Measures related to mental health

Mental health construct	Measure/Instrument	Reported by	Article
Well-being	Quality of Life (non-scale)	Staff (administrators)	Artmann et al., 2017
Well-being	Quality of Life (non-scale)	Staff; relatives	Cioffi et al., 2007
Well-being	Affect Rating Scale (ARS) *	Trained observers	Cox et al., 2004
Well-being	Dementia Quality of life Instrument (DEMQOL) *	Residents (or proxy report by relatives)	Edwards et al., 2013
Well-being	Perceptions of benefits to residents (e.g. happiness, improved mood, memory stimulation)	Staff; relatives	Hernandez, 2007
Well-being	Perceptions of residents feeling happy, revitalised	Residents	Kearney & Winterbottom, 2005
Well-being	Perceptions of impact of plants on dementia patients; (e.g. mental stimulation, memory, orientation, sense of purpose, promote conversation)	Staff	Rappe & Topo, 2007
Well-being	Residents' overall feeling after being outdoors: 'much worse'; 'slightly worse'; 'same'; 'slightly better'; 'much better'.	Residents	Rodiek, 2006
Depression	Cornell Scale for Depression in Dementia *	Staff and residents	Edwards et al., 2013
Stress	Perceptions of residents' stress levels	Staff	Hernandez, 2007
Stress	Systolic and diastolic blood pressure; heart rate.	Residents (objectively measured)	Ottosson & Grahn, 2005

'Quality of Life (non-scale)' means that a Quality of Life scale (instrument) was not used, instead the term was used descriptively.

* Survey measure/instrument for which validity and/or reliability have been reported.

Table 2. Greenery exposure and measures

Greenery exposure	Measure	Reported by	Article
Garden presence	Presence of garden	Staff (administrators)	Artmann et al., 2017
Garden presence	Presence of wander garden (after moving to new care facility)	Staff; relatives	Cioffi et al., 2007
Garden presence	New wander garden (replacing traditional garden)	Staff; residents; relatives	Edwards et al., 2013
Garden presence	Exposure to garden (through windows)	Staff; relatives	Hernandez, 2007
Garden use	Perceptions of garden use (including frequency)	Staff (administrators)	Artmann et al., 2017
Garden use	Perceptions of use of wander garden (after moving to new care facility)	Staff	Cioffi et al., 2007
Garden use	Use of garden (compared with usual living room)	Staff; relatives	Cox et al., 2004
Garden use	Frequency of use of garden	Staff; residents; relatives	Edwards et al., 2013
Garden use	Perceptions of use	Staff; relatives	Hernandez, 2007
Garden use	Frequency of use of outdoor areas (including garden)	Residents	Kearney & Winterbottom, 2005
Garden use	Use of garden for resting (compared with favourite room indoors)	N/A - Experimental condition	Ottosson & Grahn, 2005
Plants (indoors and outdoors) presence	Perceptions of presence of plants	Staff	Rappe & Topo, 2007
Use of outdoor areas with greenery	Perceptions of use	Residents	Rodiek, 2006

Table 3. Summary of associations between greenery and mental health

Mental Health Outcome	Greenery	
	Presence	Use
Well-being	○ ●●●●	○ ●●●●●●● □
Depression	○	○
Stress		● □

○: Positive (expected) association based on validated outcome measures

□: No association based on validated outcome measures

●: Positive (expected) association based on non-validated outcome measures

Supplementary Table 1. Details of papers included in review

Article; Country	Participants	Study design	Data collection methods	Outcome measures	Greenery measures	Analytical approach	Findings
Artmann et al., 2017; Austria, Germany, Norway, Poland, Romania, Slovenia	Administrators (n=126) of RACFs	Observational	Survey	Quality of life (QoL) – questionnaires refer to this generally without a specific definition	Presence of useable garden at RACF; use of garden, frequency of use	Descriptive only.	Most RACFs (62%) had a usable garden. Social interaction (63%) was considered the most important QoL benefit (related to mental health). Non mental-health QoL benefits were physical activity (66%), especially walking (95%) and gardening (64%).
Cioffi et al., 2007; Australia	Staff members (n=12) and relatives (n=7) of residents relocated to a new dementia-specific special care unit	Quasi-experimental	Focus groups conducted at 3 months and at 6 months post-relocation	Perceived quality of life of residents (no particular definition)	Presence of freely accessible dementia garden with wander paths, pavilion and bus-stop	Thematic analysis	Staff and relatives perceived that the extra space in the garden area and autonomy regarding garden access improved the overall quality of life of residents.
Cox et al., 2004; Australia	Part 1: Residents of RACF with dementia (n=24; female 96%, (n=23)) Part 2: 6 caregivers (staff), 6 relatives	Quasi-experimental	Part 1: Cross-over (within-subjects) design; residents did activities in garden, and living room. Part 2: interviews re perceptions of how residents respond to these settings	Observation instrument was the Affect Rating Scale (ARS). Positive affect categories of pleasure, interest, and contentment are assumed as visible signs of feelings of well-being.	Use of garden (compared with living room) during individual 16-minute sessions.	Friedman test of significance - a non-parametric test for testing the difference between several related samples. Wilcoxon signed-rank test was used to examine differences in ratings of affect obtained before and during sessions in each environment.	There were no significant differences in rates of pleasure experienced by residents in the garden (43%) or living room (46%), or in respective rates of interest (15%, 24%) or contentment (30%, 25%). However, during one-on-one care with a caregiver, rates of experiencing pleasure increased significantly (p<0.001), in both environments suggesting the importance of one-on-one care in all settings.
Edwards et al., 2013; Australia	Residents (n=10; aged 79-90 years; 10% male; 7 had Alzheimer's, 2 had dementia)	Quasi-experimental	Summative evaluation	Quality of Life Instrument (DEMQOL, DEMQOLProxy), Cornell Scale for Depression in Dementia (CSDD)	Presence of new wander garden; garden use was logged for 12 days 3 months prior to construction of new wander garden, and for 12 days post-construction.	t-test	Overall, frequency of garden use increased by 22%. Residents' mean quality of life score increased by 12.8% (t=4.57, df=9, p<0.0001), their mean depression score decreased by 13.3% (t=2.4, df=9, p=0.02).
Hernandez, 2007; USA	Staff (n=28), family members (n=12) at two special care units for residents with dementia	Observational	Interviews with staff and family members	Perceived benefits to residents related to their garden use	Exposure to garden (through windows); use of garden	Thematic analysis	Perceived psychological benefits for residents included happiness during garden visits, improved mood and greater interest in indoor pursuits after being outdoors. Other perceived benefits included reduction in stress.
Kearney & Winterbottom, 2005; USA	Residents (n=40, non-Alzheimer's disease) from 3 aged-care facilities	Observational	Semi-structured interviews	Perceived value of greenspace. Perceived benefits of spending time in greenspace and outdoors.	Frequency of use of outdoor areas (including garden)	Descriptive analysis	Residents valued greenspace highly, for access to fresh air (38%), and considered their interaction with this natural setting was important for feeling happy (23%), physically better (18%) or revitalized (15%).

Ottosson & Grahn, 2005; Sweden	Residents (n=15; 13.3% male) of aged-care homes	Quasi-experimental	Measurement of physiological indicators of stress before and after visit to garden and favourite room	Stress – systolic and diastolic blood pressure; heart rate; pulse pressure; rate pressure product.	Use of garden (compared with favourite room indoors)	Differences in before/after values were examined using Wilcoxon Rank Sum Tests.	There were no effects on blood pressure or heart rate. However, those with low psycho-physiological balance, i.e. who had low tolerance of other residents, were not helpful in group activities and who visited hospital often, were most affected by a garden visit, as shown by change in heart rate and blood pressure.
Rappe & Topo, 2007; Finland	Study 1: Staff members (n=65; all female) at residential homes for dementia patients Study 2: Day care dementia patients (n=73) and residential care dementia patients (n=50); higher % of females	Observational	Survey to examine the role of plants in the well-being of dementia patients	Staff perceptions of aspects of residents' mental well-being.	Exposure to plants: outdoors and indoors. All facilities were single storied with accessible outdoor areas.	Survey responses were analysed using descriptive statistics, cross-tabulation and Chi-square test. Open-ended questions were analysed by qualitative content analysis and using a phenomenological approach.	Staff agreed that plants can stimulate residents' memories (98%); caring for plants can help maintain their functional ability (94%); plants can promote awareness of changing seasons (84%) and help residents' orientation (75%). Residents are happy when receiving plants (97%) and feel needed when nurturing plants (97%). Plants promote conversation between staff and residents (95%) and amongst residents (60%).
Rodiek, 2006; USA	Residents (n=211; 70% female; mean age 84 years, range 61-99 years) of 14 assisted living facilities (15 from each facility). All were cognitively and functionally able to participate and able to reach outdoor areas unaided.	Observational	Focus groups; written surveys were used to explore residents' outdoor usage and preferences.	Overall feeling after being outdoors; time spent outdoors per week; perceived value of outdoors;	Use of outdoor areas (including greenery) within RACF	Descriptive	Most residents (74%) felt better after being outdoors. Some had problems using outdoor space due to design features (32%), concerns about safety or security (29%), insects/weather (23%), or accessibility issues with pavements (43%) or doors (25%). Greenery was the most preferred natural environment feature (30%).

RACF: Residential Aged Care Facility

Figure caption

Figure 1. Study flow diagram

Disclosure of interest

The authors report no conflict of interest.