Sunlight accessibility indoors and mental health: evidence from a social housing community in Glasgow, Scotland

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Abstract

This paper presents preliminary findings of a pilot study undertaken to investigate if access to sunlight in the home may be a factor influencing psychological health of residents of social housing in Glasgow. The study also sought to investigate underlying pathways and mechanisms, in particular the bactericidal effect of sunlight. The study was undertaken in the Shawlands area of Glasgow in October 2012. Forty residents living in four tower blocks were recruited: 24 male and 16 female, 21-70 years. Psychological health was assessed using the Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS) and the General Health Questionnaire (GHQ12). Sunlight accessibility indoors was defined using two metrics: Sunlight Aperture Opportunity (SAO) and Sunlight Surface Opportunity (SAO), m^2 hr yr^{-1}, with modelling undertaken using Integrated Environmental Solutions Virtual Environment. WEMWBS was positively associated with living room SSO with occlusion from curtains and blinds taken into account, SSO_{CB} (r_s = .322, p = .043), and living room carpet bacteria was marginally significant (r_s = .300, p = .06). For a subgroup of individuals who spent > 2 h / day in their living room between 9am – 6pm (n = 18), the relationship between WEMWBS and living room SSO_{CB} was stronger than for the sample as a whole (SSO_{CB} r_s = .733, p = .001), and living room SSO_{CB} accounted for 40% of variance in WEMWBS (adj. R^2 = .367, p = .005). GHQ12 was not associated with any sunlight metrics but there was a significant inverse association with living room carpet bacteria (r_s = -.402, p = .010), accounting for 13% of variance in GHQ12 (adj. R^2 = .106, p = .023). These findings indicate that access to sunlight in the home may be an important factor influencing the psychological health of residents of social housing in disadvantaged areas of Glasgow. Further research is warranted.

Introduction

There is a growing body of evidence from hospital and workplace environments that supports the premise that rooms which receive more sunlight are better for health, or are more salutogenic[1-3], but there is little evidence in the context of housing[4]. This paper reports preliminary findings of a pilot study undertaken to investigate if access to sunlight in the home may be a factor contributing to the mental health of residents of social housing in Glasgow. The study also sought to explore underlying pathways and mechanisms, in particular bacterial disinfection by sunlight and quality of sleep.

Methods

Survey and monitoring. The study was undertaken in the Shawlands area of Glasgow (55°N) in October 2012. Forty residents living in four tower blocks were recruited to the study: 24 male and 16 female, aged 21-70 years (mean age 41-50). Flats occupied by study participants were on floors 1 to 20, distributed approximately equally across the four buildings. Half (n = 20) of the sample had a living room with windows facing south (main window 2 x 0.73 m x 0.98 m) and west (second window: 0.55 x 0.98 m); one-third of participants (n = 13) had a living room with windows facing north (main) and east (second); 4 flats had living room windows facing east (main) and north (second); 1 flat had living room windows facing east (main) and south (second); and two flats had living room windows facing west (main) and south (second). Thus, for the living rooms, there was an overall gradient of increasing incident sunlight across aspect of the main living room window: N, E, W, S.

Mental health and wellbeing was assessed using two widely used self-report measures of psychological health: (i) the Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS); *Mental wellbeing*; and (ii) the General Health Questionnaire (GHQ12); *Psychological distress*. The survey also recorded: physical activity; sleep quality; diet; curtain/blind usage; ventilation habits; perceived quality of the indoor environment; and demographics. Additionally, environmental conditions inside each dwelling were assessed at the time of survey, including: illuminance; relative humidity, temperature and CO_2; bacteria and funghi levels in the air and living room carpet; dustmite in the living room carpet.

Modelling. Sunlight accessibility was modelled for theoretical clear sky conditions using Integrated Environmental Solutions Virtual Environment software, contracted to a private company. Two sunlight metrics were defined and simulated: *Sunlight Aperture Opportunity (SAO)* – the cumulative total area of window receiving direct solar radiation each hour over a year (m^2 hr yr^{-1}); and *Sunlight Surface Opportunity (SSO)* – the cumulative total internal surface area illuminated by direct solar radiation each hour over a year (m^2 hr yr^{-1}). SAO and SSO were simulated for the living room and kitchen of each dwelling for (i) the whole day, and (ii) between 9am and 6pm (considered typical 'up and about' time). SSO was also calculated with level of occlusion from curtains and blinds as observed at the time of survey taken into account, SSO_{CB}.

Statistical Analysis. Relationships between mental health outcomes and environment variables were assessed using correlational analysis and hierarchical blocked multiple linear regression, controlling for gender, age, physical activity levels (moderate-strenuous activity in the last 3 months – 5 point scale), and sleep quality (typical occurrence of 7-8 hours sleep per night over the last 3 months – 6 point scale). Analyses were undertaken for the sample as a whole (n = 40), and two subgroups of individuals who typically spent (a) > 2 hours (n = 18), and (b) ≤ 2 hours (n = 18) in their living room each day between the hours 9am and 6pm (survey responses indicated that the living room was the room that was used most during those hours).

Results

Mental health outcomes

WEMWBS scores ranged from 21-70 units with a mean of 49 (SD = 12.2), equal to the Scottish population average for the same year[5]. GHQ12 scores ranged from 0-12 units with a median score of 2.5 (IQR = 5). Twelve participants (30%) had a GHQ12 score ≥ 4 (the threshold indicating the presence of a possible psychiatric disorder), and ten participants (25%) had a score of 0 (indicating psychological wellbeing with no symptoms of medical distress). These values indicate significantly poorer psychological health in the study group compared to the Scottish population (for 2012 GHQ12 ≥ 4 was 15%, and GHQ12 = 0 was 62%)[5]. There was no significant difference in WEMWBS or GHQ12 by gender, or between living room use subgroups. WEMWBS and GHQ12 were both significantly associated with general health (WEMWBS: r_s = .426, p = .006; GHQ12: r_s = -.319, p = .045), but not with sleep quality or physical activity.

Relationships between mental health outcomes and environment variables

Mental wellbeing. WEMWBS was positively associated with living room SSO_{CB} (r_s = .322, p = .043) and living room $SSO_{CB\_9am\text{-}6pm}$ (r_s = .333, p = .036), but not with any other sunlight metrics, and there was no significant trend with aspect of the living room main window (Figure 1). WEMWBS was also significantly associated with living room mean, min and max relative humidity (mean RH: r_s = .399, p = .016) and living room mean CO_2 (r_s = .341, p = .042). Living room carpet bacteria was borderline significant (r_s = .300, p = .06), with higher levels of wellbeing associated with higher levels of bacteria, the opposite of what might be expected (living room carpet bacteria levels ranged from 0 (or below the limit of detection, BLD: 50 cfu/0.1g dust) to 583 cfu/g dust [x1000], with a median of 37.5 (IQR = 109) cfu/g dust [x1000]). In the regression analysis, RH was the only variable that was a significant predictor of WEMWBS, accounting for 17% of variance (adj. R^2 = .143, p = .013), but living room $SSO_{CB\_9am\text{-}6pm}$ was a marginally significant predictor (ΔR^2 = .082, p = .066), and its inclusion strengthened the model overall (adj. R^2 = .204, p = .009). None of the control variables included in the analysis were significant predictors. For the subgroup of individuals who spent > 2 h / day in their living room between 9am – 6pm, the relationship between WEMWBS and SSO_{CB} was stronger than found for the sample as a whole (SSO_{CB} r_s = .733, p = .001). WEMWBS was also significantly associated with level of occlusion of the living room main window at time of survey (r_s = -.548, p = .018) and living room mean RH (r_s = .562, p = .029). There was no association with carpet bacteria levels. Living room SSO_{CB} was able to account for 40% of variance in WEMWBS (adj. R^2 = .367, p = .005). None of the other variables included in the analysis were significant predictors. For individuals who typically spent ≤ 2 h / day in their living room between 9am – 6pm, there was no significant association between WEMWBS and any of the environment variables included in the analysis.

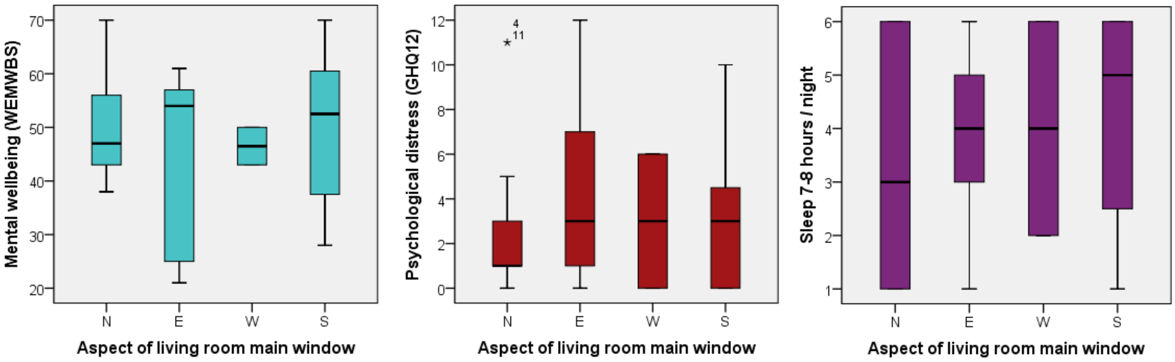

Figure 1. Mental wellbeing (WEMWBS), psychological distress (GHQ12), and sleep quality shown across aspect of the living room main window. Due to the configuration of living room windows across the study sample there was an overall increasing gradient in incident sunlight, or sunlight aperture opportunity (SAO), for the living room across aspect of the main window of: N, E, W and S (from left to right on the plots). There was no trend in WEBWBS or GHQ12 with aspect, but sleep quality increased across the SAO gradient.

Psychological distress. GHQ12 was not significantly associated with any of the sunlight metrics, for the sample as a whole or either of the subgroups, but there was a significant inverse association with living room carpet bacteria levels (r_s = -.402, p = .010), with higher levels of psychological distress associated with lower bacteria levels (again, the opposite of what might be expected, but concurrent with findings for WEMWBS). GHQ12 was also significantly correlated with kitchen min temperature (r_s = .327, p = .039) and living room max CO_2 (r_s = -.340, p = .043). In the regression analysis living room carpet bacteria levels predicted 13% of variance of GHQ12 (adj. R^2 = .106, p = .023). Kitchen min temp was also a significant predictor, accounting for 11% of variance in GHQ12 (adj. R^2 = .091, p = .027). For a binary variable of GHQ12 split at 4 (the threshold indicating the presence of a possible psychiatric disorder), there was a significant difference in living room carpet bacteria between the low distress (GHQ12 < 4, n = 28) and high distress (GHQ12 ≥ 4, n = 12) groups (U = 79.5, p = .008). Bacteria levels in the living room carpet were higher for the low psychological distress group: 0 – 583 cfu/g dust [x1000], with a median of 57 (IQR = 124), whilst for the high psychological distress group levels ranged from 0 – 251 cfu/g dust [x1000], with a median of 15 (IQR = 36) cfu/g dust [x1000]. For individuals who typically spent > 2 h / day in their living room between 9am – 6pm, GHQ12 was not significantly associated with any of the environmental variables, but level of occlusion of the living room second window at the time of survey was marginally significant (r_s = .453, p = .059), with psychological distress increasing with level of occlusion, as expected. For individuals who typically spent ≤ 2 h / day in their living room between 9am – 6pm, GHQ12 was not significantly associated with any of the environment variables, but for cases of GHQ < 10 only (n = 16) there was a significant inverse association with living room carpet bacteria (r_s = -.501, p = .048).

Relationships between bacteria levels and sunlight metrics

There were no significant associations between any of the sunlight metrics and bacteria levels in the air or the living room carpet, for the sample as a whole, or either of the subgroups, and there was no trend in bacteria levels across aspect of the living room main window. For the living room user subgroup (> 2h / day) there were marginally significant inverse associations between kitchen air bacteria and kitchen $SSO_{9am\text{-}6pm}$ (r_s = -.452, p = .059), and living room air bacteria and kitchen SSO (r_s = -.426, p = .078) – both correlations potentially indicating a sunlight bactericidal effect. However, these associations are counterbalanced by an inverse correlation between living room air bacteria and level of occlusion of the living room main window at time of survey (r_s = -.444, p = .065). For individuals who spent ≤ 2 h / day in their living room between 9am – 6pm, living room carpet bacteria was inversely associated with living room $SSO_{CB\_9am\text{-}6pm}$ (r_s = -.420, p = .083), again borderline significant and indicating a possible bactericidal effect, but this too was offset by an inverse association between living room air bacteria and level of occlusion of living room windows (main and second window combined, based on photos taken at time of survey; r_s = -.421, p = .082). Kitchen air bacteria was also marginally significant associated with level of occlusion of the living room windows (r_s = -.428, p = .076).

Relationships between sleep quality and environment variables

Sleep quality was positively associated with living room SAO (r_s = .500, p = .035) and living room SSO (r_s = .498, p = .035), as expected, and living room $SAO_{9am–6pm}$ (r_s = .433, p = .073) and living room $SSO_{9am–6pm}$ (r_s = .437, p = .070) were borderline significant correlates. Sleep was also significantly associated with living room carpet bacteria (r_s = -.488, p = .040), with sleep quality decreasing with increasing levels of bacteria. Average sleep quality increased across aspect of the main living room window (Figure 1), but this trend was not statistically significant. For the living room use subgroup (> 2h / day), sleep quality was positively associated with living room SAO (r_s = .529, p = .024), living room SSO (r_s = .525, p = .025), living room mean temperature (r_s = .572, p = .026), and kitchen mean (r_s = .535, p = .033) and min (r_s = .483, p = .042) temperature. Residents of flats with the living room main window facing south reported much better quality of sleep compared to those with a north-facing living room main window: an average of 'always' getting 7-8 hours / night, compared to 'never' getting 7-8 hours / night (p = .069). For individuals who typically spent ≤ 2 h / day in their living room between 9am – 6pm, there was no significant association between sleep quality and any of the environment variables.

Discussion and conclusions

The findings presented here are from a small pilot study using simple modelling of sunlight accessibility indoors, but clearly indicate a link between sunlight accessibility in the home and mental health and wellbeing, suggesting that access to sunlight indoors is likely to be an important factor influencing the psychological health of residents of social housing in disadvantaged areas of Glasgow, especially for individuals who spend much of their time at home. The results also indicate that access to natural light indoors may be influencing sleep quality, as expected[6], but sleep quality was not found to be linked with psychological health. Bacterial disinfection by sunlight does not appear to have been a major mechanism at work, however the marginally significant relationships observed for the two living room use subgroups could potentially indicate a bactericidal effect (> 2h subgroup: inverse associations between kitchen air bacteria and kitchen $SSO_{9am\text{-}6pm}$, and living room air bacteria and kitchen SSO; ≤ 2 h subgroup: living room carpet bacteria and living room $SSO_{CB\_9am\text{-}6pm}$). As evidence these correlations are counterbalanced by the inverse associations observed between bacteria levels and window occlusion, but window occlusion estimates are expected to have a relatively large error as they represent the situation as observed on one day only (open to influence by weather conditions on the day of survey), and variations in the transmittance of curtain and blind materials were not taken into account in the modelling. More accurate modelling of sunlight using actual weather conditions for Glasgow for the year of survey and use of sunlight metrics for October only (the month of survey) could also potentially yield more statistically significant relationships, as bacterial samples are representative of the time of survey and both measures of mental health record psychological health for a relatively short time period (e.g. WEMWBS relates to the two weeks prior to survey). Nevertheless, the observation of better mental health where there was higher levels of bacteria for both measures of mental health used suggests a more complex picture. This pattern could reflect cleaning habits negatively impacting on health through depletion of beneficial bacteria in the environment[6], or, similarly, ventilation habits[7]. Further research into the effects of sunlight on health and wellbeing in the housing context is warranted.

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