PEER REVIEW HISTORY

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ARTICLE DETAILS

TITLE (PROVISIONAL)	Older people, the natural environment and common mental disorders: cross-sectional results from the Cognitive Function and Ageing Study
AUTHORS	Wu, Yu-Tzu; Prina, A.Matthew; Jones, Andrew; Matthews, Fiona; Brayne, Carol

VERSION 1 - REVIEW

REVIEWER	Kirsten Beyer Assistant Professor Medical College of Wisconsin, USA
REVIEW RETURNED	08-Apr-2015

GENERAL COMMENTS	This paper presents a cross-sectional, secondary data analysis examining the relationship between natural environmental features and mental health (depression, anxiety) among men and women ages 65 and older in England who participated in the Cognitive Function and Ageing Study. The main contribution of the paper is to add to the existing literature about the relationship between green/natural space and mental health; the authors argue that the paper is one of few to contribute to knowledge about this relationship among older age groups. While the paper is well-written and the topic is of much interest, several methodological and conceptual issues limit the impact of the paper. Major concerns: A number of papers have now investigated this topic; quite a few of which the authors do not cite. Several of the key papers in this field of study come from research groups in England (e.g. Wheeler, White, et al.) and are quite relevant to the work described in this manuscript. The authors are encouraged to explore the literature more deeply to identify papers that they may have overlooked, and include and discuss their findings in the context of this larger body of work. The authors must also consider the scope of their contribution. They argue that "the association between natural environments and common mental disorders, important health problems with practical and clinical significance, has not been investigated using consistent outcome measures of mental disorders, coupled with objectively defined environmental exposure estimates, in a large sample of older people across England." While this may be the case, it is a very focused and small research gap specific to particular measures, age groups, and one country. Can the paper contribute more than this?

While it would be valuable to have more information about the relationship between natural environments and mental health among older people, the more valuable contribution would be to compare relationships among different age groups through stratified analyses, to identify not only whether the relationships are detected, but how they compare to relationships identified in other age groups. In this paper, we receive only a story about older people with no basis for comparison.

The authors do not control for population density or any indicator of urbanicity/rurality; this is a key omission, as more densely populated areas are often less green. The authors argue that they do not have enough of a rural sample, but they state that the full sample is n=2424 and the sample from rural areas is n=380. I do not see a small sample size problem in examining differences by rurality, and a population density variable could be used in any case.

The authors take length of residence into account through sensitivity analyses, but do not control for it, it appears, in models. This choice should be justified, and potentially explored analytically. In addition, they rely on a response to a survey question asking "have you moved in the last 2 years?" For a longitudinal study, is there no record of addresses over time that could be used to weight historical exposure data to improve exposure estimates? As neighborhood selection bias is a key weakness in cross-sectional studies, this should be more carefully considered.

Generally, what is meant by "green space" and the way it is measured in the primary exposure variable is not well described and should be explained in more detail for those who are not regular users of this database. In particular, it is of concern that this measure is not detailed, given the lack of attention to urban/rural differences and the different manifestations of green space in these different contexts.

It seems strange to mention (page 17) the results of other work in this paper, without actually presenting those results. Are those intended for another paper? Why not include those analyses in this paper, given the important differences between urbanicity and rurality where natural environments are concerned?

Minor concerns:

There is a typo on page 19: "areas to be associated with lower levels [OF] income-related health inequality…"

The consideration of co-morbidities is a strength of the paper that could be more fully discussed.

The use of abbreviation "an1" is awkward in text (in the mental disorders section on page 9)
Table 2 is quite large; the authors could consider reducing its size through reducing the number of models presented.

REVIEWER	Christopher Coutts
	Florida State U
REVIEW RETURNED	30-May-2015

GENERAL COMMENTS	This paper answers the many calls for more research into the health benefits of green infrastructure. Most of my many questions were addressed as I read through the text. I therefore only have a few comments:

This paper answers the many calls for more research into the health benefits of green infrastructure. Most of my many questions were addressed as I read through the text. I therefore only have a few comments:

1) The most critical revision needs to be the consistent and accurate use of "availability" (e.g. p.16). Availability implies access, but this is not what is being measured as the authors explicitly and rightfully state in the limitations. Luckily, mental health benefits do not require access, only exposure to nature. The authors use the term "exposure" but also "availability." Please replace all occurrences of "availability" with "exposure" for clarity and accuracy. P.20: "accessibility" and "usage" used, but these are not necessary for mental health benefits.

2) I applaud the use of the small-scale spatial unit of the LSOA, but, as the authors note in the limitations, this may not be the "most" appropriate scale but it is the best that can be done for studies with a large sample size. The LSOA is more flimsy when measuring accessibility, but that is not what was done.

3) p.12: I am more familiar with "univariate" and not "univariable."

4) A possible future direction of research might be to delve into the fact that women were twice as likely as men to have clinical depression. Is greenspace more impactful on widowers of either sex?

5) p.19: "...might therefore act [to] increase the risk..."

6) p.20: A qualitative or case/control study of use (now we really are talking about use) would reveal not just mental health benefits of exposure but also the cumulative mental and physical health benefits gained through exposure and physical activity. Mental health benefits of physical activity have been shown to be greater when activity is performed in green settings.

Thompson Coon, J., Boddy, K., Stein, K., Whear, R., Barton, J., & Depledge, M. H. (2011). Does participating in physical activity in outdoor natural environments have a greater effect on physical and mental wellbeing than physical activity indoors? A systematic review. Environmental Science & Technology, 45(5), 1761–72. http://doi.org/10.1021/es102947t

Pretty, J., Peacock, J., Sellens, M., & Griffin, M. (2005). The mental and physical health outcomes of green exercise. International Journal of Environmental Health Research, 15(5), 319–337.

Bodin, M., & Hartig, T. (2003). Does the outdoor environment matter for psychological restoration gained through running? Psychology of Sport & Exercise, 4(2), 141. http://doi.org/10.1016/S1469-0292(01)00038-3

VERSION 1 – AUTHOR RESPONSE

Reviewer: 1

Comment 1:
A number of papers have now investigated this topic; quite a few of which the authors do not cite. Several of the key papers in this field of study come from research groups in England (e.g. Wheeler, White, et al.) and are quite relevant to the work described in this manuscript. The authors are encouraged to explore the literature more deeply to identify papers that they may have overlooked, and include and discuss their findings in the context of this larger body of work.

Response:
We have cited some UK-based studies and added the following sentence in the Introduction section: "Recent studies in the UK have shown both cross-sectional and longitudinal associations between mental health and green space among younger adults.9-11 Although the literature has suggested a positive influence of natural environments on individual mental health, the associations may vary across different age groups.12" We aware that there is a large body of research on green space and mental health/wellbeing but the focus of this study is common mental disorders in later life. We decided to focus specifically on the literature related to older people.

Comment 2:
The authors must also consider the scope of their contribution. They argue that "the association between natural environments and common mental disorders, important health problems with practical and clinical significance, has not been investigated using consistent outcome measures of mental disorders, coupled with objectively defined environmental exposure estimates, in a large sample of older people across England." While this may be the case, it is a very focused and small research gap specific to particular measures, age groups, and one country. Can the paper contribute more than this?

Response:
We have revised this sentence to: "However, the association between natural environments, depression and anxiety, important mental health problems with practical and clinical significance, has not been investigated in older age groups."

Comment 3:
While it would be valuable to have more information about the relationship between natural environments and mental health among older people, the more valuable contribution would be to compare relationships among different age groups through stratified analyses, to identify not only whether the relationships are detected, but how they compare to relationships identified in other age groups. In this paper, we receive only a story about older people with no basis for comparison.

Response:
In this paper, we intentionally focus on common mental disorders in older people and explore the association with natural environment exposure. We were not able to conduct a direct comparison with younger age groups as the CFAS cohort only included people aged 65 or above from the baseline.

Comment 4:
The authors do not control for population density or any indicator of urbanicity/rurality; this is a key omission, as more densely populated areas are often less green. The authors argue that they do not have enough of a rural sample, but they state that the full sample is n=2424 and the sample from rural areas is n=380. I do not see a small sample size problem in examining differences by rurality, and a population density variable could be used in any case.

It seems strange to mention (page 17) the results of other work in this paper, without actually presenting those results. Are those intended for another paper? Why not include those analyses in this paper, given the important differences between urbanicity and rurality where natural

environments are concerned?

Response:
Since the percentage of green space is generally associated with urban/rural status, we think the consideration of urbanicity/rurality should focus on its potential modifying effect on the association between common mental disorders and natural environment rather than acting as a confounder. The characteristics of green space are different in urban (parks, gardens) and rural areas (wild nature) with an associated differential impact on mental health in later life. Previous studies (Maas et al., 2006; Mitchel & Popham, 2007), also considered urbanicity/rurality as an effect modifier rather than a confounder.

We have conducted a stratified analysis of urban/rural areas and this is presented as supplementary material. However, we consider urban/rural stratification to be a sensitivity analysis and only present these results in the appendix due to some substantial limitations. Since 90% of the rural population was in the highest quartile of the natural environment, it was not possible to investigate the association in rural areas or examine the interaction terms between natural environment exposure and urban/rural categories. The statistical power of this rural population (N=380) was insufficient to detect the effect of the natural environment on common mental disorders (prevalence<0.3) using a multilevel model adjusting for five individual level factors (age, men/women, high/low education, high/low social class, none/one/two or more chronic conditions) and area deprivation quartiles. Estimates would be uncertain with wide confidence intervals.

We have provided more detailed information on the stratified analysis of urban/rural areas and revised the text in the Discussion section: "Although the concept of "greenness" might be different in urban and rural areas8, 30, the rural population in CFAS was small (N=380, 15.7%) and skewed with 90% in the highest quartile of the natural environment exposure. It was therefore not possible to examine if associations with exposure to the natural environment differed between those in rural and urban areas. We did however conduct a sub-analysis focusing solely on the urban population and found a somewhat stronger relationship between natural environment exposure, depressive and anxiety symptoms (Table S1, supporting information)."

Mitchell R, Popham F. Greenspace, urbanity and health: relationships in England. J Epidemiol Community Health. 2007;61:681-3.
Maas J, Verheij RA, Groenewegen PP, de Vries S, Spreeuwenberg P. Green space, urbanity, and health: how strong is the relation? Journal of Epidemiology and Community Health. 2006;60(7):587-92.

Comment 5:
The authors take length of residence into account through sensitivity analyses, but do not control for it, it appears, in models. This choice should be justified, and potentially explored analytically. In addition, they rely on a response to a survey question asking "have you moved in the last 2 years?" For a longitudinal study, is there no record of addresses over time that could be used to weight historical exposure data to improve exposure estimates? As neighborhood selection bias is a key weakness in cross-sectional studies, this should be more carefully considered.

Response:
The reason of not adjusting for moving in the regression model is that moving was considered to be an "outcome" of poor health status and poor quality of the living environment. Controlling for moving could therefore lead to over-adjustment. However, we also considered that people who had moved in the past 2 years might not experience the long term influence of natural environment exposure on mental health. Thus, we conducted a sensitivity analysis excluding those who had moved in the past 2 years to test whether the results remained similar.

The CFAS follow-up wave was conducted after 2 years from the baseline and then focused on sub-samples every two years. Only the 10 year follow-up included all survivors and responders. The record of address over time was not available for this analysis and using information from the questionnaire was a more systematic method.

Comment 6:
Generally, what is meant by "green space" and the way it is measured in the primary exposure variable is not well described and should be explained in more detail for those who are not regular users of this database. In particular, it is of concern that this measure is not detailed, given the lack of attention to urban/rural differences and the different manifestations of green space in these different contexts.

Response:
We have added the definition of green space, "areas with natural vegetation such as grass, trees and plants", in the Introduction section. We also provide more detailed information on the measure of natural environment and add the following sentences in the Method section: "The measure of natural environment exposure employed was the percentage of green space and private gardens in each LSOA based on the Generalised Land Use 2001 Dataset (GLUD), which provides areas of different types of land use in thousands of square metres for all the LSOAs across England (data.gov.uk/dataset/land_use_statistics_generalised_land_use_database). Green space was defined as areas covered with grass and private gardens were grounds adjacent to houses."

Comment 7:
There is a typo on page 19: "areas to be associated with lower levels [OF] income-related health inequality…"

The use of abbreviation "an1" is awkward in text (in the mental disorders section on page 9)

Table 2 is quite large; the authors could consider reducing its size through reducing the number of models presented.

Response:
We have revised the typo and replace "an1" with "anxiety level of one or above". We would like to remain the detailed information on the three models but we have separated Table 2 into two tables (Table 2a and 2b) in order to present these results clearly.

Comment 8:
The consideration of co-morbidities is a strength of the paper that could be more fully discussed.

Response:
We have added a section of strength in the Strengths and limitations section and discussed the strength of considering co-morbidities: "The CFAS interview also collected detailed information on co-morbidities and therefore their potential confounding effects could be taken into account in the analysis."

Reviewer 2

Comment 1:
The most critical revision needs to be the consistent and accurate use of "availability" (e.g. p.16). Availability implies access, but this is not what is being measured as the authors explicitly and rightfully state in the limitations. Luckily, mental health benefits do not require access, only exposure to nature. The authors use the term "exposure" but also "availability." Please replace all occurrences of "availability" with "exposure" for clarity and accuracy. P.20: "accessibility" and "usage" used, but these are not necessary for mental health benefits.

Response:
We have replaced the availability with "exposure" throughout the manuscript. We believe that supporting older people to use local green space can also increase their exposure of natural environment with potential mental health benefits. We have revised the sentence to "Land-use

planners need to consider further ways in which to best support older people using local green space as promoting use of green space in older adults may help support healthy ageing."

Comment 2:
I applaud the use of the small-scale spatial unit of the LSOA, but, as the authors note in the limitations, this may not be the "most" appropriate scale but it is the best that can be done for studies with a large sample size. The LSOA is more flimsy when measuring accessibility, but that is not what was done.

Response:
We agree that LSOA is the best that can be done using the method of data linkage. However, compared to studies using GIS technologies, the spatial scale of LSOA might not be the most ideal to define the exposure of natural environment for individuals.

Comment 3:
p.12: I am more familiar with "univariate" and not "univariable."

Response:
"Univariable" and "univariate" indicate different types of regression models (Peters, 2008). We think that using the term "univariable" is more appropriate in this context.

Peters TJ. Multifarious terminology: multivariable or multivariate? univariable or univariate? Paediatr Perinat Epidemiol. 2008;22(6):506. doi: 10.1111/j.1365-3016.2008.00966.x.

Comment 4:
A possible future direction of research might be to delve into the fact that women were twice as likely as men to have clinical depression. Is greenspace more impactful on widowers of either sex?

Response:
We agree that this is a possible research direction. We have suggested further investigation of the usage of green space in various subgroups in Future research directions but we feel that the exploration of widowhood and gender is beyond the scope of this study.

Comment 5:
p.19: "...might therefore act [to] increase the risk..."

Response:
We have revised this error.

Comment 6:
p.20: A qualitative or case/control study of use (now we really are talking about use) would reveal not just mental health benefits of exposure but also the cumulative mental and physical health benefits gained through exposure and physical activity. Mental health benefits of physical activity have been shown to be greater when activity is performed in green settings.

Response:
We have revised the following text in Future research directions and added the relevant reference in the manuscript: "Since mental health benefits of physical activity have been shown to be greater when activity is performed in green settings43-45, more detailed information on the usage of green space in older populations could be provided by qualitative studies that investigate various subgroups such as gender, ethnicity and socioeconomic status, and also from quantitative studies that employ technologies such as global positioning systems and audit tools to track activity patterns.46,47 Different types and qualities of green space might also have differential influences on the mental health of older people and a better understanding of how green space characteristics might influence

their use and cumulative mental health benefits through outdoor activity is needed."

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VERSION 2 – REVIEW

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REVIEWER	Christopher Coutts Florida State University, USA
REVIEW RETURNED	17-Jul-2015

GENERAL COMMENTS	I am satisfied that the authors addressed my concerns as best as possible considering data constraints.