Response to Invited Commentary

Knuiman et al. Respond to “Time-Varying Neighborhood Environments”

Matthew W. Knuiman*, Hayley E. Christian, Mark L. Divitini, Sarah A. Foster, Fiona C. Bull, Hannah M. Badland, and Billie Giles-Corti

* Correspondence to Matthew W. Knuiman, School of Population Health (M431), The University of Western Australia, 35 Stirling Highway, Crawley, WA 6009, Australia (e-mail: matthew.knuiman@uwa.edu.au).

Initially submitted May 27, 2014; accepted for publication June 2, 2014.

We are pleased that our article (1) describing and interpreting analyses of longitudinal data from a natural experiment on the relationship between neighborhood built environment characteristics and walking for transportation has generated debate (2). This will help to clarify the advantages and limitations of longitudinal data and the complexities surrounding the interpretation of results from various modeling approaches to such data, especially the issue of controlling for time-invariant and time-varying confounders, and the possible association of participant drop-out that is common in such studies. The commentary has extended our discussion and elaborated further on a number of issues inherent in seeking to establish a stronger evidence base for a possible causal relationship from longitudinal data.

We agree that careful interpretation of results from various analysis strategies is warranted. Indeed, it was an aim of our article to discuss, compare, and contrast 3 modeling approaches. The commentators have expressed a clear preference for using marginal models (method 1 in our original article (1)) and have largely ruled out any utility of fixed-effects models (method 3) because those do not provide estimates for time-invariant factors. We do not view these different modeling approaches as competitors; rather, each modeling approach has its own advantages that should be exploited, and a careful and thorough analysis should involve multiple modeling approaches, not necessarily a single approach. For example, the fact that fixed-effects models automatically control for all measured and unmeasured time-invariant factors is a feature to be exploited. Further, the similarities between subject-level effect estimates from the mixed-effects model (method 2) and those from the fixed-effects model (method 3) for a time-varying built environment feature as we have demonstrated allow for a more robust conclusion. This is especially important in settings such as this, in which randomized trials of built environment changes on walking behavior are impractical and natural experiments with longitudinal data are recommended as the preferred approach (3). A drawback of marginal models (method 1) in the context of participant drop-out is that the validity of estimates depends on the rather strict assumption of data being missing completely at random, whereas the subject-level models (methods 2 and 3) remain valid under less restrictive assumptions when fitted with likelihood-based approaches (4).

It is well established that the appropriate and effective strategy for investigating built environment effects on health is to use context-specific outcome and built environment variables (5). Although the overall Residential Environments (RESIDE) Study was designed to study multiple outcomes, walking for transportation within the neighborhood was a priori the main outcome variable of interest in that analysis. The focus on walking in the neighborhood (as compared with total walking or total physical activity level) is the appropriate specific outcome for investigating the specific associations with the participants’ neighborhoods, as both were assessed at the same spatial level. Further, there is evidence that different features of the built environment are important for walking for transportation and recreational walking, and this explains the specific attention on walking for transportation in the neighborhood. The associations of neighborhood built environment features with walking for recreation should be the subject of a separate article.

Lovasi and Goldsmith express concern that walking for transportation alone may have a limited impact on chronic disease. In previous work (6), we found that people who undertook a range of behaviors (walking for transportation plus walking for recreation or some vigorous activity) were much more likely to achieve the recommended levels of total activity. Walking for transportation should be considered one of a number of physical activities that should be undertaken during the course of the day. Moreover, there are numerous co-benefits from increasing walking for transportation, and it is now being promoted by organizations as diverse as the...
Organisation for Economic Co-operation and Development and leading health authorities (7–9).

**ACKNOWLEDGMENTS**

Author affiliations: Centre for the Built Environment and Health, School of Population Health, The University of Western Australia, Perth, Australia (Matthew W. Knuiman, Hayley E. Christian, Mark L. Divitini, Sarah A. Foster, Fiona C. Bull); and McCaughey VicHealth Centre for Community Wellbeing, Melbourne School of Population and Global Health, University of Melbourne, Melbourne, Australia (Hannah M. Badland, Billie Giles-Corti).

The Residential Environments Study was funded by grants from the Western Australian Health Promotion Foundation (grant 11828), the Australian Research Council (grant LP0 455453), and an Australian National Health and Medical Research Council Capacity Building Grant (458688). B.G.-C. was supported by a National Health and Medical Research Council Principal Research Fellow Award (grant 1004900). H.E.C. is supported by a National Health and Medical Research Council/National Heart Foundation Early Career Fellowship (grant 1036350), and S.A.F. is supported by a Healthway Health Promotion Research Fellowship (grant 21363).

Conflict of interest: none declared.

**REFERENCES**