Health impacts of the M74 urban motorway extension: a mixed-method natural experimental study

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Declared competing interests of authors: David Ogilvie, Richard Prins, Andy Jones, Hilary Thomson and Shona Hilton report additional funding from the Medical Research Council. David Ogilvie, Louise Foley, Richard Prins and Andy Jones report additional funding from the UK Clinical Research Collaboration. Andy Jones is a member of the Research Funding Board of the National Institute for Health Research (NIHR) Public Health Research programme. Nanette Mutrie reports additional funding from the NIHR.

Disclaimer: This report contains transcripts of interviews conducted in the course of the research and contains language that may offend some readers.

Published April 2017
DOI: 10.3310/phr05030

Scientific summary

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Public Health Research 2017; Vol. 5: No. 3
DOI: 10.3310/phr05030

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Background

The case for urban regeneration is consistent with a social ecological model of health, in which economic conditions, as well as physical and social environments, are seen as important influences on health and well-being. However, the evidence that initiatives of this kind have produced the outcomes claimed for them is far from conclusive. One particularly contentious type of intervention is the construction of new major roads in urban areas. Although new roads make it easier for people to travel around and can improve access to employment, education and other opportunities, motor transport also incurs substantial societal costs through injuries, pollution and other undesirable impacts. In contrast, a population shift towards walking, cycling and public transport offers a potentially winning combination of an increase in physical activity coupled with reductions in traffic congestion and use of fossil fuels, and is therefore increasingly regarded as desirable on public health, environmental and equity grounds.

This study was based around the opening of an extension to the M74 motorway in Glasgow, which is the largest city in Scotland and is characterised by extremes of affluence and deprivation. The intervention, which formed part of a wider strategic initiative to regenerate the 'Clyde Gateway' area, comprised a new 5-mile, six-lane section of motorway opened in 2011, along with associated changes to the urban landscape such as junctions, slip roads, and housing and retail developments. The new motorway runs through predominantly deprived neighbourhoods in south-east Glasgow, is mostly elevated above ground and is parallel to an existing railway line. Proponents claimed that the new motorway would improve conditions for pedestrians and cyclists on local streets and help to regenerate local communities, whereas objectors argued that it would encourage car use, degrade the local environment and deter local walking and cycling.

Aims

We summarised these contrasting narratives as two alternative overarching hypotheses about the effects of the intervention, articulated as contrasting 'virtuous' and 'vicious' spirals. No research study could conceivably evaluate impacts across all possible domains identified in the public discourse. The Traffic and Health in Glasgow study [Centre for Diet and Activity Research. *Traffic and Health in Glasgow*. URL: www.cedar.iph.cam.ac.uk/research/directory/traffic-health-glasgow (accessed 20 February 2017)] was therefore designed to take advantage of this natural experiment to address the following primary research questions:

1. What are the individual, household and population impacts of a major change in the urban built environment on travel and activity patterns, road traffic accidents and well-being?
2. How are these impacts distributed between different socioeconomic groups?

We also aimed to address the following secondary research questions:

1. What environmental changes have occurred in practice?
2. How are the effects of the environmental changes experienced by local residents?
3. How are any changes in behaviour or well-being mediated and enacted at individual and household levels?

Methods

This mixed-method controlled before-and-after study was built on the foundations of a baseline cross-sectional study previously undertaken in 2005 in three local study areas in Glasgow: the 'M74 corridor' intervention area ('South') and two matched control areas, one surrounding the existing M8 motorway ('East') and one with no comparable major road infrastructure ('North'). Within each area, graded measures of the proximity of the motorway to each participant's home served as a further basis for controlled comparisons. We used a combination of quantitative and qualitative methods to evaluate changes in health and health-related behaviour, and to investigate how these changes were experienced and brought about. The study comprised six main elements:

1. An environmental survey to characterise the intervention.
2. A core follow-up survey of local residents in 2013, to compare changes in neighbourhood perceptions, travel behaviour (using a 1-day travel record), physical activity (short International Physical Activity Questionnaire) and well-being [Short Form 8 Health Survey (SF-8) and the short version of the Warwick–Edinburgh Mental Well-Being Scale (SWEMWBS)] in the three study areas, using a combination of cohort and repeat cross-sectional analyses. A total of 1345 participants (mean age 49 years; 61% women) provided valid data at baseline and 1343 did so at follow-up. A total of 365 participants provided valid data at both time points and thereby formed a longitudinal cohort.
3. A detailed quantitative substudy of 196 survey participants in 2014–15 (mean age 54 years; 55% women), using accelerometers and global positioning system receivers to quantify differences in neighbourhood-specific and overall physical activity between study areas.
4. A detailed qualitative substudy involving a combination of semistructured, photovoice and walkalong interviews with 30 survey participants purposively sampled from two contrasting localities within 400 m of the new motorway, along with 12 other key informants, in 2014–15.
5. Analyses of existing national population data sets to evaluate the impact of the intervention on road traffic accidents (using police STATS19 data, 1997–2014) and to elaborate the evaluation of its impact on travel behaviour (using Scottish Household Survey travel diary data, 2009–13).
6. A programme of community and stakeholder engagement to help shape the final study design, elicit a wider range of accounts and develop a shared understanding and interpretation of the emerging findings.

Results

Changes in travel and activity patterns

In longitudinal multivariable two-part regression analyses adjusted for multiple individual and household confounders, as well as baseline travel behaviour, cohort participants living in the South (intervention) study area were significantly more likely than those in the North (reference) study area to report travel by any mode of transport at follow-up [odds ratio (OR) 2.1, 95% confidence interval (CI) 1.0 to 4.2]. Within the South study area, participants living closer to a motorway junction were more likely to report travel by any mode (cohort analysis: OR 4.7, 95% CI 1.1 to 19.7) and to report using a car (repeat cross-sectional analysis: OR 3.4, 95% CI 1.1 to 10.7) at follow-up than those living further away.

Scottish Household Survey data showed that the proportion of journey stages that were walked or cycled increased slightly over time in all three study areas, but there was no evidence that the rate of change was significantly different between intervention and control areas. Core survey data showed that the average daily quantity of active travel reported by participants decreased over time in all three areas. In multivariable two-part regression analyses, neither area- nor individual-level exposure to the intervention was associated with either the likelihood or the quantity of active travel at follow-up.

In analogous analyses, cohort participants living in the East study area (surrounding the existing M8 motorway) were less likely to report any physical activity participation at follow-up than those in the North (OR 0.4, 95% CI 0.2 to 0.9), and those living closer to a motorway junction in the East were less likely to

do so than those living further away (OR 0.3, 95% CI 0.1 to 1.0). In multivariable generalised linear model analyses of the georeferenced accelerometer data, neither area- nor individual-level exposure to the intervention was associated with physical activity, either overall or within neighbourhood pedestrian network buffers of various sizes.

Changes in road traffic accidents

The annual incidence of road traffic accidents in Glasgow City and surrounding local authorities fell by 51% between 1997 and 2014, and a similar reduction was observed in all three local study areas. Interrupted time series regression (autoregressive integrated moving average) analyses suggested no significant differences in temporal trends between study areas that could be attributed to the new motorway. The opening of the motorway had little impact on the spatial clustering of accidents.

Changes in well-being

In multivariable linear regression analyses, cohort participants living closer to the new motorway experienced significantly reduced mental well-being [mental component summary of the SF-8 scale (MCS-8)] over time compared with those living further away (coefficient –3.6, 95% CI –6.6 to –0.7). In repeat cross-sectional and cross-sectional analyses using the MCS-8 and SWEMWBS, respectively, an interaction was found whereby participants with a chronic condition living closer to the existing M8 motorway experienced a greater decrement in well-being than those living further away (MCS-8: $p = 0.06$ for interaction, area-specific coefficient –3.7, 95% CI –8.3 to –0.9; SWEMWBS: $p = 0.01$ for interaction, area-specific coefficient –1.1, 95% CI –2.0 to –0.3).

Understanding the changes

Changes in travel and activity patterns

Participants described how the physical structure of the new motorway itself, as well as related changes in traffic, noise and other aspects of their surroundings, affected active travel in both positive and negative ways. Where the motorway was seen as having a direct impact, this was most often described as affecting the quality or experience of active travel rather than the frequency, duration or routes of journeys. In contrast, perceptions of personal safety were more often linked with making changes in the frequency, route or mode of active journeys. Although the divergence of views about the motorway previously elicited at baseline was reinforced, most participants at follow-up described the new pedestrian infrastructure for crossing the motorway as lighter, more open and more secure than expected.

Local residents experienced changes to connectivity that they associated with the new motorway and other factors. Broadly, those with more dispersed social networks and access to a motor vehicle tended to view the motorway as facilitating connections with amenities and people in other places. The impacts were more complex for others, some of whom found the motorway to be a cause of severance, whether that be physically, psychologically or through its impact on local places of connection.

Changes in road traffic accidents

Qualitative accounts of travel in the local area revealed several mechanisms that may have prevented the realisation of the claimed reduction in casualties. Local residents described new hazards including the merging of lanes of traffic, vehicles travelling at high speeds on slip roads and the altered layouts of existing streets close to the new motorway junctions. These may have contributed to the danger of crossing roads, particularly for pedestrians with impaired mobility.

Changes in well-being

In cross-sectional multivariable linear regression analyses, perceptions of both the social (collective efficacy) and physical environment of neighbourhoods were slightly more negative among those living closer to a motorway, but these differences were not statistically significant; in multivariable linear regression cohort analyses, there was no evidence that changes in these perceptions mediated the changes in well-being

associated with motorway exposure. Qualitative accounts elucidated the industrial history and character of the area, longstanding concerns about pollution and, for some, narratives of decline and powerlessness in local communities, suggesting a degree of acceptance of, or resignation to, the more recent changes brought about by the motorway.

The community engagement events nevertheless elicited striking accounts of stark visual, noise, dust and other forms of disturbance among those living in extreme proximity to the new motorway. Furthermore, in longitudinal multivariable linear regression analyses, reductions in both mental and physical well-being were associated with an 'upheaval index' representing the proportion of land use within an 800-m neighbourhood pedestrian network buffer that had changed between 2005 and 2015, and its association with mental well-being was stronger in the South study area ($p = 0.052$ for interaction; area-specific coefficient –0.18, 95% CI –0.34 to –0.02).

Conclusions

Principal findings

Mapping our findings against the key propositions of the contrasting 'virtuous' and 'vicious' spirals, we found a mixture of confirmatory and disconfirmatory evidence on both sides. We found comparatively strong evidence for a harmful effect of a new urban motorway and associated infrastructure on the well-being (particularly the mental well-being) of local communities, and of an increase in travel (particularly in car use). Although the risk of residual confounding cannot be eliminated in a natural experimental study of this kind, these findings were robust to adjustment for multiple confounders and were corroborated in different analyses. We found weaker evidence of a decline in physical activity participation over the long term and no evidence of an overall increase or decrease in either the quantity of active travel or the incidence of road traffic casualties. Although these findings may indicate a truly null effect, they may also reflect the average of diverging positive and negative effects in different groups, a degree of measurement error in travel behaviour and limited statistical power to detect changes in cycling or in casualties among more vulnerable road users.

Interpretation and implications for public health policy and practice

The changes in the physical environment associated with the new motorway were widely perceived as less important than changes in the social composition and cohesion of local communities, and perceptions of personal safety. Where the design of new infrastructure, such as pedestrian overbridges, contributed to improved perceptions of personal safety, it was valued, and even those local residents with negative experiences overall admitted the convenience afforded by improved motorway access. The new motorway appeared to promote travel generally and car use more specifically, but not to influence the quantity of active travel reported by local residents. We did, however, find some evidence of a negative impact on physical activity among those living closer to an existing motorway, consistent with (although not proof of) a hypothesis that effects on physical activity are likely to be complex and to evolve over time. Together with the lack of evidence for an effect on casualty incidence, these findings suggest that, on balance, 2–3 years after the completion of the motorway, the public health benefits claimed for it in terms of walking, cycling and road traffic casualties had not been realised. Furthermore, living near to a new motorway was associated with a substantial worsening of local residents' well-being, particularly for those exposed to a greater degree of upheaval in their immediate neighbourhood. In the area surrounding an existing motorway, the negative association between proximity and well-being was concentrated among those with chronic conditions. Similarly, although the new motorway improved connectivity for those with more dispersed social networks and access to a motor vehicle, it aggravated the severance of others from local people and places.

The study identified a mixture of benefits and harms overall, and the impact of environmental changes of this kind might be experienced differently in communities lacking an industrial history and an existing plane of severance in the form of a railway line. We also acknowledge that more time may be required for

some benefits, such as economic revival (which we have not assessed directly), to be fully realised and to produce a more indirect positive impact on the health and well-being of the local population. Nevertheless, our findings clearly indicate how some of the overall health and social gains claimed for this type of investment may either not be achieved or be achieved for some at the expense of others. In particular, they highlight the potential for infrastructural interventions of this kind to add further burdens to already disadvantaged communities, to entrench or exacerbate existing social inequalities in health and to contribute to poorer health outcomes among those living with chronic conditions. The overarching hypothesis with which our data are most consistent is that new transport infrastructure is more likely to benefit more people when it connects people with their social and physical surroundings – broadly defined – more than it separates them, and when people are protected from its harmful environmental impacts by distance or other effective mitigation measures. The health and social impacts of infrastructural projects of this kind, how these are distributed in the population and how any adverse impacts might effectively be mitigated, should be more fully taken into account in future policy and planning.

Implications for public health research

Future investments of this kind should be subject to greater evaluative scrutiny, with particular emphasis on seeking to replicate and further investigate the effects we have observed on well-being, and with research resources being allocated to those natural experimental opportunities with the greatest potential to reduce scientific uncertainty about key outcomes and mechanisms. More detailed exploration of the different ways in which people interpret and interact with their physical and social environments and how these change in response to interventions and other exogenous factors could help to advance our understanding of the ways in which policy, planning and practice do or do not 'work' in this respect is needed.

Funding

Funding for this study was provided by the Public Health Research Programme of the National Institute for Health Research.

Public Health Research

ISSN 2050-4381 (Print)

ISSN 2050-439X (Online)

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This report

The research reported in this issue of the journal was funded by the PHR programme as project number 11/3005/07. The contractual start date was in January 2013. The final report began editorial review in July 2016 and was accepted for publication in December 2016. The authors have been wholly responsible for all data collection, analysis and interpretation, and for writing up their work. The PHR editors and production house have tried to ensure the accuracy of the authors' report and would like to thank the reviewers for their constructive comments on the final report document. However, they do not accept liability for damages or losses arising from material published in this report.

This report presents independent research funded by the National Institute for Health Research (NIHR). The views and opinions expressed by authors in this publication are those of the authors and do not necessarily reflect those of the NHS, the NIHR, NETSCC, the PHR programme or the Department of Health. If there are verbatim quotations included in this publication the views and opinions expressed by the interviewees are those of the interviewees and do not necessarily reflect those of the authors, those of the NHS, the NIHR, NETSCC, the PHR programme or the Department of Health.

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