

New Roads and Human Health: A Systematic Review

We sought to synthesize evidence of the health effects of construction of new roads by systematically reviewing observational studies of such effects. We included and critically appraised 32 studies.

The review suggested that out-of-town bypasses decrease injuries on main roads through or around towns, although more robust evidence is needed on effects on secondary roads. New major urban roads have statistically insignificant effects on injury incidence. New major roads between towns decrease injuries. Out-of-town bypasses reduce disturbance and community severance in towns but increase them elsewhere. Major urban roads increase disturbance and severance.

More robust research is needed in this area, particularly regarding effects of new roads on respiratory health, mental health, access to health services, and physical activity. (*Am J Public Health*. 2003;93:1463–1471)

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TRANSPORTATION IS AN

important determinant of health,^{1–3} but the World Health Organization (WHO) has recently expressed concern that the importance of a healthy transportation policy has not been fully recognized. WHO specifically refers to the issue of road travel, stating that “reliance on motorized transport, in particular road transport, continues to increase, resulting in adverse environmental and health effects.”^{1(p3)} These comments reflect a general emphasis in public health research on negative effects associated with motorized road vehicles.^{4–9}

The United States stands out as a nation where the health and well-being of individuals and communities are said to have been adversely affected by dependence on the automobile.⁴ Rates of automobile ownership

and use in America have long exceeded those found in any other country, while public transport use and walking have been in decline since at least the late 1960s.¹⁰ A range of public health and environmental concerns have been associated with these trends, including smog, urban sprawl, a rising prevalence of obesity, and their associated health problems.¹¹ Furthermore, between 1970 and 1995, 1.2 million people died on America’s roads.¹²

Although rates of automobile ownership are particularly high in the United States,⁴ the health concerns associated with motorized road travel are shared by countries across the globe, and the Red Cross has predicted that by 2020 injuries related to traffic will be the world’s third largest cause of death and disability.¹³

Road construction and automobile dependency have also been associated with community severance (i.e., reduced access to local amenities and disruption of social networks caused by a physical barrier running through the community), increased “disturbance” among residents (e.g., noise, vibration, fumes), and social inequalities.^{8,14–17}

In such circumstances, it is little wonder that the building of new roads is often contentious. Yet roads fulfill a fundamental role within local and national infrastructures, and the motorized vehicles that use them can confer benefits in terms of mobility and convenience on substantial sections of a population.¹⁸ In his well-known study of residential streets in San Francisco, Donald Appleyard summed up the paradox implicit in the relationship

between roads and the people who are affected by them: “the street has always been the scene of . . . conflict, between living and access, between resident and traveler, between street life and the threat of death.”^{14(p1)}

The building of new roads is therefore a public health issue, but the evidence base relating to the health impacts of new roads is disparate and incomplete.¹⁹ In an attempt to provide a better understanding of the positive and negative effects that new roads exert on human health and well-being, we conducted a systematic review of the relevant literature pertaining to developed countries. Our goal was to identify, assess, and synthesize primary studies that focused on new roads and included measurements of effects on human health and well-being.

METHODS

Inclusion and Exclusion

Along with the building of roads where none existed before, the definition of “new road” used in our review included new road bridges and new road tunnels, conversion of gravel tracks into hard-surface roads, and addition of lanes to existing roads (either through road widening or through converting hard shoulders into new lanes).²⁰ We defined human health impacts as including not only specific health problems but also the concept of general well-being.²¹ Illness and injuries were included, as were psychosocial effects such as community severance and disturbance.

We did not include in the review health impacts resulting from the road construction process. Moreover, we excluded studies focusing on general eco-

nomic and environmental effects resulting from construction of new roads if they did not measure human health as well.

We aimed to include studies conducted in any language, and we sought to include a range of study designs: randomized controlled trials (should any exist), before-and-after studies involving controls, before-and-after studies not involving controls, and retrospective studies involving controls (including historical controls). We also included qualitative studies of health effects.

Search Strategy

The following databases and electronic journal collections were searched from the earliest possible start date up to 2002: ABI Inform, Acompline/Urbaline, Applied Social Sciences Index and Abstracts, BOPCAS, British Humanities Index, Business Source Premier, Campbell Collaboration, Caredata Web, Catchword, Childdata, CINAHL, Cochrane Library, Dissertation Abstracts, Econlit, EI Compendex, Electronic Collections Online, EMBASE, GEOBASE, HMIC/HELMIS, International Bibliography of the Social Sciences, Index to Theses, ingenta/uncover, INSPEC, International Civil Engineering Abstracts, MEDLINE, PAIS, PLANEX, ProceedingsFirst, PsycINFO, Regard, Road Construction Network, SIGLE, Social Science Citation Index, Social Services Abstracts, Sociological Abstracts, TRANSPORT, and ZETOC. The British Library catalogue and the COPAC catalogue were also checked, and Internet sources were searched.

Bibliographies and key journals were hand searched, and experts were contacted. We initially screened 23 259 titles and

abstracts, and we retrieved 692 studies for more detailed analysis. Each study involving construction of a new road was independently assessed by 3 reviewers in terms of relevance and methodological rigor.

Critical Appraisal and Data Extraction

We adapted critical appraisal tools from those recommended within the systematic review^{22–33} and transport^{34–38} methodological literature. Each study was assessed in regard to 9 subject-specific criteria (Tables 1 and 2). These assessments were used as a guide to the methodological soundness of each study, although, as is the case with all critical appraisal tools, they relied on authors accurately describing their methods.

Some results from resident surveys were based on population proportions, while others were based on 5-point, 7-point, or 36-point scales. We recalculated these results as percentages for ease of comparison. We included confidence intervals (CIs), *P* values, and effect size ranges when they were reported in the original article or calculated these statistics if sufficient information was available.

RESULTS

Thirty-two different studies^{39–72} were identified, the earliest from 1962 (A.H. Amundsen and R. Elvik, unpublished data, 2001; M.L. Burr, G. Karani, B. Davies, B.A. Holmes, and K.L. Williams, unpublished data, 2002). Note that some studies appeared in more than one publication, while other publications included multiple studies. Eight studies were identified from electronic databases. One was identi-

fied from Web browsing, 4 were identified from personal communications, and 19 were identified from citation follow-ups.

Most of the studies examined either disturbance among local residents or road injuries. No studies were identified that examined the impact of new roads on access to health care, health inequalities, or physical activity. There was sparse evidence on outcomes involving specific physical or mental illnesses. The one exception was an unpublished article that examined respiratory symptoms and respiratory function after the opening of a new road (M.L. Burr, G. Karani, B. Davies, B.A. Holmes, and K.L. Williams, unpublished data, 2002).

Road Injuries

Table 1 summarizes the results of studies assessing effects of new roads on injury prevalence rates. Seven of the injury studies involved meta-analyses of data from more than one new road site (A.H. Amundsen and R. Elvik, unpublished data, 2001).^{41–43,45–47} The other 4 studies in this category examined the impact of a single new road on injuries.^{39,40,44,48} The studies covered 3 broad categories of roads: major urban roads (4 studies), out-of-town bypasses (5 studies), and major connecting roads between towns (3 studies). One study included both bypasses and major connecting roads.⁴⁵ All involved the use of before-and-after comparisons of police injury statistics adjusted for general trends.

Major urban roads take traffic through urban areas. Out-of-town bypasses are designed to take traffic away from urban areas. Major connecting roads usually join 2 urban areas, relieving

TABLE 1—Summary of Studies Showing Effects of New Roads on Injuries

Study Details	Methods ^a	Effect on Injury Accidents and Casualties (Adjusted for General Trends)
Major urban roads		
Amundsen and Elvik (unpublished data, 2001): Norway, 4 roads	1 2 3 5 6 7 9	19% decrease in injury accidents, including secondary roads
Jadaan and Nicholson ³⁹ : New Zealand, 1 road	1 2 3 4 5 6 7	4% decrease in injury accidents, main roads only
Sæverås ⁴⁰ : Norway, 1 road	1 2 3 5 7 8 9	4% decrease in injury accidents
Levine et al. ⁴¹ : US, 2 roads	1 2 3 4 5 9	1% decrease in no. of casualties per injury accident
		26% decrease in injury accidents (note: this figure has since been recalculated to 8.5%) ³⁵
	1 2 3 4 6 9	1% decrease in injury accidents
Bypasses		
Andersson et al. ⁴² : Denmark, 11 roads	1 2 3 5 6 8 9	4% decrease in injury accidents 6% increase in casualties
Elvik et al. ⁴³ : Norway, 20 roads	1 2 3 4 5 6 7	19% decrease in injury accidents
Jørgensen ⁴⁴ : Denmark, 1 road	1 2 3 5 8 9	No change in rate of injury accidents (regional trends) 3% decrease in casualties (regional trends)
Leeming ⁴⁵ : UK, 19 roads	1 2 3 5 6 7	33% decrease in injury accidents
Newland and Newby ⁴⁶ : UK, 7 roads	1 2 3 6 7	25% decrease in injury accidents
Major connecting roads		
Jensen ⁴⁷ : Denmark, 2 roads	1 2 3 5 6 9	25% decrease in injury accidents
Leeming ⁴⁵ : UK, 5 highways, 39 dual carriageways, 37 lane additions to 2-lane roads	1 2 3 5 6 7	19% decrease in injury accidents: highways 32% decrease in injury accidents: dual carriageways 22% decrease in injury accidents: lane additions to 2-lane roads
Newby and Johnson ⁴⁸ : UK, 1 road	1 2 3 7 8 9	6% decrease in casualties

^a1 = control for general trends; 2 = reliable/representative sample of data; 3 = sufficient data presented to validate results; 4 = control for regression to the mean; 5 = assessment at least 3 years before and 3 years after; 6 = compares more than one new road; 7 = injury severity considered; 8 = no. of individual casualties included; 9 = accident migration across wider road network considered.

TABLE 2—Summary of Studies Showing Effects of Major Urban Roads on Disturbance Among Local Residents

Study Details (No. of Roads, Before/After Sample, Follow-Up From Date Road Opened)	Methods ^a	Change in Disturbance, %	Reported Effect Range, % (per Road)
Hawley ⁴⁹ : Australia, 1 road, n = 308/367, 2-3 years	1 3 4 6 7 9	Noise: +3	...
Griffiths and Raw ⁵⁰ : UK, 1 road, n = 42/not reported, 2-3 months	1 2 3 4 7 9	Noise: +24	...
Lee et al. ⁵¹⁻⁵³ : UK, 5 roads, n = 960, 5, 10, 30 years	1 3 5 6 7 8	Severance: +14 (mean % trips across road)	5 years: +15 10 years: +13 30 years: +14
Lawson and Walters ⁵⁴ : UK, 1 road, n = 189/174, 11 months	1 4 6 9	Noise: "significant" increase (no figures presented)	...

^a1 = appropriate sampling; 2 = response rate/follow-up > 60%; 3 = controls/adjustment for confounders; 4 = appropriate exposure measures; 5 = adaptation to disturbance considered; 6 = impact on secondary roads considered; 7 = sufficient data presented to validate results; 8 = compared more than one new road; 9 = prospective study.

variable. Two studies revealed negligible decreases in the incidence of accidents involving injuries (4% and 1%, respectively).^{39,41} Two others revealed statistically significant decreases (19% and 26%) (A.H. Amundsen and R. Elvik, unpublished data, 2001),⁴⁰ although reexamination of data from the second study suggests that an estimated decrease in incidence of 8.5% is more accurate than the figure of 26% provided.³⁵

One study examined 4 new major urban roads in Oslo and estimated a mean decrease in injury accidents of 4% when only major roads were considered and a decrease of 19% when secondary roads were included (A.H. Amundsen and R. Elvik, unpublished data, 2001). The authors noted that there were systematic variations in the results of the 4 projects. Three of the roads were new tunnels that together were associated with an estimated increase in injury accidents of 10% (95% CI = -8%, 32%) on major roads. The fourth site consisted of road-widening and intersection improvements to an existing road; in this case, injury accidents decreased by an estimated 51% (95% CI = 27%, 68%).

Bypasses. The 5 bypass studies showed a general decline in the incidence of injury accidents after the opening of new bypasses. This decline was statistically significant in 2 studies, both of which were published in the 1960s.^{45,46} In a recent meta-analysis of 20 bypasses in Norway, the observed decrease in injury accidents of 19% was statistically significant when a fixed effects model was used in the analysis (95% CI = 5%, 30%) but was narrowly rejected by significance testing when a random effects model was used

older connecting road networks that run through largely rural areas. They are not primarily designed to relieve traffic in urban

areas.⁴⁵ In instances in which study information was unclear, authors were contacted to clarify details of the roads examined.

Major urban roads. All 4 of these studies considered the effects of new roads on the wider local network. The results were

(95% CI=-35%, 0.4%).⁴³ All of the studies in this category compared the incidence of injury accidents on main through roads in the “before” period with the incidence of injury accidents on both old through roads and new bypasses in the “after” period.

In addition to examining old through roads and new bypasses, 2 studies also included adjacent (secondary) roads in their analyses of injury accidents.^{42,44} Each study detected small, statistically insignificant decreases. Andersson et al. found a mean increase in the incidence of injury accidents of 41% along secondary roads that linked new out-of-town bypasses to old main roads that ran through towns.⁴² However, this figure included accidents that took place on intersections between the bypasses and the old through roads. Injuries on the old through roads and the new bypasses (but excluding the intersections, where one would expect a large proportion of the accidents to occur) decreased by a mean of 20%.⁴²

Major connecting roads. Two of the 3 studies in this category revealed statistically significant reductions in rates of injury accidents. In a study focusing on the construction of 2 highways, Jensen estimated that these roads reduced injury accidents by a mean of 25% (taking secondary roads into account).⁴⁷ Leeming estimated that new highways and new dual carriageways reduced injury accidents by 19% and 32%, respectively (on major roads only).⁴⁵

Newby and Johnson presented data on casualty rates but not data on injury accidents⁴⁸; they found that casualty incidence rates fell by 6% after the opening of a new highway (no confidence intervals or significance

tests were provided). They examined effects on the secondary road network within 30 miles (48 km) of either side of the new road. The size of the area under investigation could explain the relatively small decrease detected; the effects were greatest on roads within 5 miles of the new highway.

Casualties and injury severity. Most injury studies measured the effects of new roads by examining the incidence of accidents involving injury, but 3 studies also examined numbers of individuals listed as casualties of road accidents.^{39,42,44} There was no consistent evidence of a significant difference between the 2 types of measurement in assessing the impact of new roads. The initial results of one study did show a significant increase in casualties but not in injury accidents.⁴² However, the authors concluded that this finding was biased by their inclusion of an atypical site in their meta-analysis.

There was little consistent evidence of significant changes in accident severity, possibly because severe and fatal accidents occur relatively infrequently. Leeming found that new connecting roads were associated with a significant decrease in fatal and serious injury accidents (28%; $P < .05$) but not a significant decrease in fatal accidents alone (7%; $P > .05$). Conversely, adding a single overtaking lane to a 2-lane road significantly reduced the rate of fatal accidents (48% decrease; $P < .05$) but not the rate of fatal and serious accidents combined (10% decrease; $P > .05$).⁴⁵

Jadaan and Nicholson provided unadjusted data on injury severity in a study of a new major urban road. There was a marked difference between the

road's effect on minor injury accidents (10% increase) and the effect on fatal and serious injury accidents (48% decrease).³⁹ Amundsen and Elvik's study of new major urban roads showed a 23% decrease in serious and fatal accidents (A.H. Amundsen and R. Elvik, unpublished data, 2001).

Leeming estimated that construction of bypasses led to statistically insignificant ($P > .05$) decreases in serious/fatal injuries combined (12%) and fatal injuries alone (6%).⁴⁵ Andersson et al. did not conduct a direct analysis of data on injury severity but inferred an increase in severity from the increase in the mean number of casualties per injury accident.⁴²

Disturbance

Twenty-one studies⁴⁹⁻⁷² involved the use of structured and semistructured surveys to consider the impact of new roads on disturbance (M.L. Burr, G. Karani, B. Davies, B.A. Holmes, and K.L. Williams, unpublished data, 2002). They focused on major urban roads and bypasses. Types of disturbance included noise, vibration, fumes, and dirt. Some of the studies also considered community severance.

Eleven of the studies were prospective.^{49,50,54-64,66} Another 3 compared disturbance levels before and after road construction by means of retrospective questionnaires.^{65,67,68} One post-construction survey estimated preconstruction conditions by comparing intervention areas with control areas that contained no roads of the type under examination.⁵¹⁻⁵³ An additional 5 studies made no attempt to estimate preconstruction disturbance levels, focusing exclusively on the issue of adaptation to

new roads after they had opened.^{55,69-72} One post-construction study examined respiratory symptoms and functioning (M.L. Burr, G. Karani, B. Davies, B.A. Holmes, and K.L. Williams, unpublished data, 2002). In most of the studies, before-and-after comparisons were not subjected to significance testing. Studies that compared more than one site often presented data on effect size ranges for each new road. We have included these data in our tables in instances in which they were available.

Major urban roads. There were 4 studies of new major urban roads (Table 2). Three examined disturbance from traffic noise, all of which reported increases.^{49,50,54} One reported a minor increase of 3% from a prospective survey involving a new road in a residential area.⁴⁹ This road was intended to relieve congestion from another urban road. A survey of residents living near the relieved route showed a 20% decrease in the prevalence of respondents reporting disturbance. The other 2 noise studies surveyed only residents living near the new road.^{50,54} Both reported a mean increase in resident disturbance, although one did not provide data.⁵⁴

One study investigated the issue of community severance.⁵¹⁻⁵³ Neighborhood traversal was found to be an average of 14% lower in areas surrounding new roads. However, residents living in these areas partially adapted to the barrier effect produced by the major roads by expanding the boundaries of what they considered to be their neighborhood to include amenities situated further away from their homes but on their own side of the road.

TABLE 3—Summary of Studies Showing Effects of New Bypasses on Disturbance Among Residents of the Area Being Bypassed

Study Details (No. of Roads, Before/After Sample, Follow-Up From Date Road Opened)	Methods ^a	Change in Disturbance, %	Reported Effect Range, % (per Road)
Griffiths and Raw ^{50,55} : UK, 5 roads, n = 469/391, 3 months, 22 months	1 2 3 4 5 7 8 9	Noise, 2-3 months: -35 Noise, 17-22 months: -32	-60, -28 ...
Prescott-Clarke ⁵⁶ : UK, 2 roads, n = 562/552, 1 year	1 2 3 4 6 8 9	Noise: -6 Vibration: -5 Fumes: -3 Dirt: -5	-8, -3 -6, -3 -3, -2 -8, -2
Baughan and Huddart ⁵⁷ : UK, 9 roads, n = 407/338, 1-2 months	1 2 3 4 8 9	Noise: -39	-51, -22
Morrissey and Hedges ⁵⁸ : UK, 2 roads, n = 208/120, 14 months	1 4 5 7 8 9	Noise: -40 Vibration: -27 Fumes: -23 Dirt: -36 Severance: -17	-43, -36 -30, -24 -24, -21 -38, -33 -23, -11
Fullerton et al. ⁵⁹ : UK, 2 roads, n ≈ 430/505, follow-up length not reported	2 4 6 7 8 9	Noise: -41 Vibration: -16 Fumes: -17 Dirt: -13 Severance: -8	-51, -30 -13, -19 -17, -16 -13, -12 ...
Mackie et al. ⁶⁰⁻⁶² : UK, 2 roads, n = 205/198, 3-6 months	1 4 6 7 8 9	Noise: -31 Vibration: -44 Fumes: -23 Dirt: -41 Sleep disturbance: -21	-46, -15 -69, -19 -41, -5 -70, -11 ...
Brown et al. ⁶³ : Australia, 1 road, n = 49/92, 15-21 months	2 3 4 6 9	Noise: -45	...
Dawson ⁶⁴ : UK, 1 road, n = 142/136, 1 year	1 4 6 7 9	Sleep disturbance Main road: -4 Secondary roads: +1
Nilsson ⁶⁵ : Sweden, 9 roads, n = 3327, follow-up length not reported	2 3 6 8	Noise: -4 Vibration: -3 Fumes: -4 Severance: -8
Haakenaasen ⁶⁶ : Norway, 1 road, n = 64/68, 1 year	1 7 8 9	Noise: 0 Noise, night only: -33
Mehra and Lutz ⁶⁷ : Germany, 1 road, n = 82, follow-up length not reported	1 4 6	Noise: -7	-35, +28
Mudge and Chinn ⁶⁸ : UK, 1 road, n = 237, 7 years (results give details of indoor/outdoor disturbance)	6 7	Noise: -34/-41 Vibration: -38/-45 Fumes: -45/-45 Dirt: -43/-48 Severance: .../-50

^a1 = appropriate sampling; 2 = response rate/follow-up > 60%; 3 = controls/adjustment for confounders; 4 = appropriate exposure measures; 5 = adaptation to disturbance considered; 6 = impact on secondary roads considered; 7 = sufficient data presented to validate results; 8 = compared more than one new road; 9 = prospective study.

Bypasses. The 12 bypass studies (Table 3) revealed a general decrease in disturbance among residents of towns being bypassed.^{50,55-68} This decrease generally occurred on the towns' secondary roads as well as main roads. Small towns tended to experience the largest decreases in through traffic as a result of new bypasses, and consequently they experienced greater benefits in terms of reduced disturbance.^{50,55,60-62}

One important source of bias in many of these studies was a failure to consider disturbance among rural residents living near the bypass. However, 3 studies did present numerical data on this issue.^{56,64,67} Prescott-Clarke stated that the bypass examined increased the percentages of rural residents disturbed by noise, both when they were indoors (11% increase) and when they were outdoors (15% increase).⁵⁶ Dawson stated that the proportion of rural residents reporting sleep disturbances increased by 22%.⁶⁴ Mehra and Lutz reported a mean increase in noise disturbance of 79% among residents living in areas where traffic noise increased after the opening of a bypass.⁶⁷

Adaptation and respiratory health. Three quantitative studies investigated adaptation to disturbance after the opening of major urban roads (Table 4).⁶⁹⁻⁷¹ They showed no evidence of adaptation. The one qualitative study conducted was perhaps more sensitive to adaptation than the quantitative surveys. This qualitative study reported that adaptation occurred in the following domains: attitude (e.g., reconciling oneself to the inevitability or usefulness of the new road), behavior (e.g., spending less time

TABLE 4—Summary of Studies on Disturbance After the Opening of New Roads: Postconstruction Only

Study Details (No. of Roads, Samples, Length of Follow-Up From Road Opening)	Methods ^a	Outcome, %	Reported Effect Range, % (per Road)
Major urban roads			
Jonsson and Sörensen ⁶⁹ : Sweden, 1 road, n = 84/60, 18 months	1 2 3 4 5 7	Noise: +12 Sleep disturbance: +46 Tiredness, headache, nerves: +17	...
Morrissey and Hedges ⁷⁰ : UK, 2 roads, n = 219/142, 15 months	1 4 5 7 8	Noise: +3 Vibration: +8 Fumes: +3 Dirt: +8 Severance: +3 Sleep disturbance: 0	0, +5 +2, +13 +2, +3 +7, +9 +1, +5 -1, +1
Weinstein ⁷¹ : US, 1 road, not reported/n = 160, 16 months	1 3 4 5 7	Noise Cohort study: +5 Repeat cross-sectional study: -4	...
Bypasses			
Griffiths and Raw ⁵⁵ : UK, 5 roads, n = 414/430, 7 years	1 2 3 4 5 7 8	Noise: +6	Range: -9, +15
Qualitative			
Hedges ⁷² : UK, 4 major urban roads, 1 bypass, interviews (n = 24) and focus groups (n = 60), 5 years	Appropriate sampling Use of interviews and focus groups Sufficient use of quotes to validate conclusions Multisite comparison	Major urban roads increase all types of disturbance and severance; residents adapt their behavior and attitudes and make changes to home environment to mitigate effects of new road Bypass decreases all types of disturbance and severance; no strong evidence of residents being less appreciative of the benefits over time (i.e., no evidence of adaptation)	

^a1 = appropriate sampling; 2 = response rate/follow-up > 60%; 3 = controls/adjustment for confounders; 4 = appropriate exposure measures; 5 = adaptation to disturbance considered; 6 = impact on secondary roads considered; 7 = sufficient data presented to validate results; 8 = compared more than one new road; 9 = prospective study.

in certain rooms of one's house), and environment (e.g., installing fences).⁷² Quantitative and qualitative studies of bypasses did not provide any consistent evidence of adaptation to decreased disturbance.^{55,72}

A draft article by Burr et al. was the only study identified in this review to measure specific respiratory health impacts resulting from a new road (M.L. Burr, G. Karani, B. Davies, B.A. Holmes, and K.L. Williams, unpublished data, 2002). The authors found that, during the first year after a bypass opening, there was little consistent evidence of improvements in respi-

ratory symptoms or decreases in peak expiratory flow variability among town residents attributable to the opening of the bypass. There was a net decrease of 10.3% in the prevalence of rhinitis affecting activities among residents of congested streets in comparison with residents of uncongested streets (95% CI = 3.1%, 17.3%). In addition, there was a significant improvement in peak flow variability among residents of uncongested streets in the morning but not the evening. Interpretation of the results was complicated by an observed trend involving improved lower

respiratory function among residents of the bypassed town's uncongested streets, a trend that may have been attributable to the bypass or to confounding factors.

DISCUSSION

Impact of New Roads

The utility and desirability of new roads should be assessed in terms of their impact on the economy, the general environment, and the health and well-being of individuals most immediately affected. This review has synthesized the available evidence base pertaining to

only one of these categories: health and well-being. Systematic reviews of the other 2 categories are also required. We plan to conduct such a review of economic effects in the near future.

Overall, there was little evidence that new major urban roads significantly reduce the incidence of injury accidents, except for a study of widening and intersection improvements made to a single urban road in Norway (A.H. Amundsen and R. Elvik, unpublished data, 2001). New major urban roads appear to increase noise disturbance and severance effects in local communities. There is qualitative, but not quantitative, evidence that residents may respond to these effects via behavioral, attitudinal, and environmental adaptation. However, in one study increased disturbance could still be detected 3 years after the opening of a new road,⁴⁹ and other studies showed that evidence of severance effects could still be detected 30 years after road openings.⁵¹⁻⁵³

The evidence on out-of-town bypasses indicates that they reduce the incidence of injury accidents on main routes through or around towns. Secondary roads within towns may be affected differently (e.g., the Andersson et al. study⁴² suggests that bypasses lead to increases in injuries on secondary roads and intersections). Unfortunately, detailed accident statistics are not always available for secondary roads (A.H. Amundsen and R. Elvik, unpublished data, 2001), which perhaps explains the relative lack of robust evidence on how new bypasses affect the distribution of injury accidents across broader road networks.

New bypasses reduce disturbance among residents of bypassed towns, especially small towns, and one study showed a beneficial effect on minor nasal symptoms (M. L. Burr, G. Karani, B. Davies, B. A. Holmes, and K. L. Williams, unpublished data, 2002). Although new bypasses reduce the amount of disturbance in some communities, people living near the bypasses themselves typically experience adverse effects (which were addressed in only a few studies).^{56,64,67} Similarly, there is evidence that major new roads connecting urban centers are associated with significant decreases in accident injuries, but there is no evidence regarding the effects on rural residents.

Research Implications

The present review has collated the available evidence on the impact of new roads on human health and well-being. Our search was to some extent hampered by poorly indexed transport databases, reinforcing the claims made by Wentz et al.¹⁹ regarding the need to improve the electronic referencing of transport studies. Despite an extensive literature search, most of the studies included in this review were not found in electronic databases. This suggests that systematic reviews of non-clinical topics, particularly in the area of transportation, may need to rely more on citation searching, hand searching, bibliographies, and contacts with experts than on searches of electronic databases.

The quality of the studies identified was generally low, although some of the problems arose from methodological difficulties inherent in conducting quasi-experimental assessments

of environmental modifications. Frequently occurring potential sources of bias included nonrandomized sampling, low response and follow-up rates, overreliance on inadequately tested self-assessment questionnaires, lack of controls, and lack of long-term longitudinal studies. Disturbance studies were generally subject to more methodological problems than injury studies. Although we were able to identify directions of effects in the disturbance studies reviewed, heterogeneity in the measurement of outcomes prevented us from comparing specific effect sizes between studies.

One would normally expect to see an inverse relationship between methodological robustness and effect size, but the present review provides little consistent evidence of this so-called “iron law” of evaluation.⁷³ Bypass injury studies represented an exception: those that included observations of secondary roads registered smaller effects than those that did not.

This review has identified a bias in favor of measuring effects among urban as opposed to rural communities. Future research should aim to redress this situation and fill evidence gaps surrounding the impacts of new roads on access to health services, physical activity, health inequalities, and the health effects of specific pollutants. More rigorously designed prospective studies should also be carried out to assess the size and distribution of wider health impacts of new road schemes. Disturbance studies show that residents benefit from reduced traffic volumes. Alternative interventions designed to reduce traffic in residential areas should also be evaluated so that their

costs and benefits can be compared with those of new road programs.

Summary

The results of this review will be of value to public health professionals and others seeking to estimate the potential health and social effects of new road building. Our findings will also contribute to the wider debate on the social determinants of health, among which transport and related policies are currently seen as playing a major role. Our overall results suggest that, contrary to the sometimes expressed view that new road construction has only negative effects, new roads have a range of positive and negative effects on health that vary according to type of road and population under consideration. ■

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Contributors

M. Egan planned the study; collected, analyzed, and synthesized the data; and wrote the article. M. Petticrew supervised study planning, assisted in data analysis and synthesis, and contributed to the writing of the article. D. Ogilvie assisted in data analysis and synthesis and contributed to the writing of the article. V. Hamilton assisted in data collection and analysis and contributed to the writing of the article.

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