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Road traffic noise exposure scenarios in Malmö 2025 – 2040

Mikael Ögren
Göteborgs universitet, Box 414, SE-40503 Gothenburg, Sweden, mikael.ogren@amm.gu.se

Andreas Gustafson
VTI, Gothenburg, Sweden, andreas.gustafson@vti.se

Manne Friman, Claes Ockborn Kastby
Soniqa Akustik AB, Karlskrona, Sweden, manne.friman@soniqa.se claes.kastby@soniqa.se

Mårten Spanne
Miljöförvaltningen Malmö stad, Malmö, Sweden, marten.spanne@malmo.se

This study assesses present and future road traffic noise exposure in Malmö, Sweden, for the period 2025 – 2040. Using projected traffic flow data and the Nord2000 calculation method, façade noise levels were modelled for a set of scenarios, including reduced traffic volumes, lowered speed limits, increased market penetration of low-noise tyres, and expanded implementation of noise barriers. Population exposure was quantified for each scenario, and the corresponding health effects were estimated in terms of annoyance, sleep disturbance, and cardiovascular disease risk. Health outcomes were translated into disability-adjusted life years (DALYs) following WHO methodologies. The scenarios demonstrate substantial variation in long-term noise exposure, with the largest reductions achieved when combining other measures with low-noise tyre adoption. Corresponding declines in DALYs indicate that targeted noise-mitigation strategies could significantly reduce the future health burden attributable to road traffic noise in Malmö. The results provide an evidence base for evaluating municipal noise policies and for guiding long-term urban planning aimed at improving public health.

1 Introduction

Road traffic noise is one of the most widespread environmental stressors in European cities, with the World Health Organisation estimating that more than 110 million people in the EU are exposed to levels exceeding recommended thresholds [1]. Chronic exposure is associated with cardiovascular disease, sleep disturbance, and annoyance, contributing measurably to the overall burden of disease [2], [3]. Under the Environmental Noise Directive [4], member states are required to produce strategic noise maps and action plans for major agglomerations, but these typically report only the number of people above fixed thresholds and do not translate exposure into health outcomes. A health-impact framework based on DALYs provides a more informative basis for comparing the effectiveness of different interventions.

Malmö, the third-largest city in Sweden with over 360,000 inhabitants, faces a traffic noise situation typical of mid-sized European cities: a dense inner city with high road traffic flows, residential buildings along arterial roads, and limited space for conventional mitigation. The city is engaged in long-term planning towards 2040 and beyond, with several competing strategies under consideration — including traffic redistribution, speed reductions, noise barriers, and technological improvements to vehicles. Evaluating these strategies on a common basis, using the same population data and acoustic model, allows their relative effectiveness to be directly compared.

This paper presents noise exposure calculations for the municipality of Malmö across six scenarios spanning 2025 to 2040, introducing noise reduction scenarios based both on traffic management, barriers and tyre noise reduction. For each scenario, exposure is reported in terms of population above standard thresholds and as total health burden in DALYs, using dose–response functions from the WHO Environmental Noise Guidelines [3] and disease rates from the GBD 2023 study [2] for Sweden.

2 Methods

2.1 Road traffic noise calculations

Road traffic noise was calculated for the municipality of Malmö, situated in southern Sweden, using the Nord2000 propagation method [5] as implemented in the commercial software SoundPlan. Receiver points were distributed across residential building facades throughout the municipality. Building footprint polygons, including height attributes, were provided by the City of Malmö and processed to meet the requirements of the calculation software. A ground impedance layer was obtained from a previous noise calculation model for Malmö and reused without modification.

Two sets of receiver points were produced. In the first, receivers were placed on each floor of every building, allowing floor-by-floor exposure to be resolved. In the second, all receivers were placed at a uniform height of 4 m above ground, consistent with the methodology used for END strategic noise maps [4]. Key calculation parameters are listed in Table 1.

Table 1. Key parameters used in the SoundPlan noise calculations.

Parameter	**Value**
Max source search range	3000 m
Number of reflections	2
Max reflection distance	100 m
Allowed tolerance	1.0 dB

2.2 Population and receiver matching

Population data were obtained from Statistics Sweden (SCB) and the Swedish Mapping, Cadastral and Land Registration Authority (Lantmäteriet), providing georeferenced address points linked to individual residents. Each address point was matched to the corresponding building polygon using the apartment designation (lägenhetsnummer). For the floor-resolved receiver set, the number of floors per building was derived from the same attribute; where this information was absent, ground floor was assumed.

Each address point was matched to a receiver point using a search radius of 15 m in the horizontal plane. Receiver points are placed at the midpoint of each façade segment, with a maximum spacing of 15 m for long continuous façades (mean spacing 9.6 m, median 9.2 m); the search radius is therefore sized to guarantee that at least one receiver per façade segment is always within reach. Since typical building widths in Malmö are 5–10 m, the radius also ensures that receivers on the road-facing façade are always included in the candidate set for buildings oriented parallel to the road.

The building to which an address point belongs was identified using the building footprint area attribute of the geometrically closest receiver within the search radius; all candidates sharing that footprint area were then retained. From this set the receiver with the highest L_{Aeq} was selected as the representative exposure point for the dwelling, on the basis that health impact assessment should reflect the most exposed façade rather than the entrance side, which may be shielded.

For the floor-resolved receiver set, candidates were additionally filtered to the floor matching the resident's registered floor; if no exact match was found, the nearest floor within ±1 was accepted as a fallback, with the floor offset recorded. Population points with no match in any scenario within the search radius and floor constraints were excluded from the analysis.

2.3 Traffic flow

Traffic flow data for the reference case (Base 2025) was provided by the City of Malmö, including road-by-road counts, vehicle speeds, and medium/heavy vehicle proportions. The Business as Usual 2040 (BAU 2040) scenario was based on a traffic growth prognosis developed by the City of Malmö, applying projected increases in vehicle kilometres travelled to the 2025 network.

The traffic mobility programme (TROMP 2040) scenario represents a targeted traffic management strategy in which through-traffic in the inner city is redistributed to reduce residential exposure. The vehicle mix shifts towards a larger share of public transport and a correspondingly lower share of light vehicles, with a slight increase in heavy vehicles on the remaining high-flow corridors.

The Calm Traffic Zone 2040 (CTZ 2040) scenario introduces reduced speed limits of 30 km/h on inner-city roads close to dwellings. Lower speeds cause some traffic to redistribute onto higher-capacity roads around the city centre, concentrating flows away from the densest residential areas.

2.4 Noise reduction scenarios

The Barriers 2040 scenario represents an ambitious and potentially expensive but realistic noise barrier programme. Barriers were placed only at locations where construction would be physically feasible, and all positions were determined manually by an experienced acoustician familiar with barrier planning practice. The total barrier network comprises [35 km total length, average height 3.5 m] of barriers. Despite the scale of the intervention, the placement constraints ensure that the scenario reflects what could possibly be built, although other constraints such as financial cost, land ownership and landscape impact are not taken into account.

The Tyre −3 dB scenario is a simplified representation of future reductions in tyre–road noise. A uniform 3 dB reduction is applied to all road links in the BAU 2040 traffic network, representing the reduction achievable for mixed traffic with tyre technologies currently available or near to market [6]. This scenario does not account for any changes in traffic flow or vehicle mix, isolating the acoustic effect of quieter tyres. All scenarios are summarised in Table 2.

Table 2. Overview of noise reduction scenarios.

Short name	Description	Year
Base	Current traffic flows and network, reference case	2025
BAU 2040	Business as usual; traffic growth prognosis by the City of Malmö	2040
TROMP 2040	Traffic redistribution in inner city; increased public transport share	2040
CTZ 2040	Calm Traffic Zone; 30 km/h speed limit in central city, traffic redistributed to outer roads	2040
Barriers 2040	Ambitious but feasible noise barrier programme	2040
Tyre −3 dB	BAU 2040 with uniform −3 dB tyre noise reduction applied to all roads	2040

2.5 Health impact assessment

Health impacts were assessed following the methodology proposed by the World Health Organisation in the Environmental Noise Guidelines for the European Region [3], using Disability-Adjusted Life Years (DALYs) as the summary measure of disease burden. The approach quantifies the fraction of disease burden attributable to noise exposure through the Population Attributable Fraction (PAF), defined as the proportion of cases that would be avoided if noise exposure were eliminated. For prevalence-based endpoints (sleep disturbance and annoyance) the burden is calculated directly from the exposed population and a disability weight (DW) [7].

Dose–response functions for annoyance and sleep disturbance from road traffic noise were taken from the WHO guidelines [3], and background disease rates were obtained from the Global Burden of Disease study 2023 (GBD 2023) for Sweden [2]. The health endpoints included in the analysis are listed in Table 3. Population growth between the base

year (2025) and the 2040 scenarios was accounted for by applying a growth factor of 1.028 (0.187 % increase per year over 15 years, based on Swedish national projections) to absolute outputs; percentage-based results are unaffected.

Table 3. Health endpoints included in the DALY assessment. DW = disability weight.

Health endpoint	Metric	Method	Dose–response source	Disease rate source
Ischaemic heart disease (IHD)	L_{den}	PAF	WHO 2018 [3]	GBD 2023 [2]
Stroke	L_{den}	PAF	WHO 2018 [3]	GBD 2023 [2]
Hypertension (residual)	L_{den}	PAF	WHO 2018 [3]	GBD 2023 [2]
Highly sleep disturbed (HSD)	L_{night}	Prevalence × DW	EC 2002 [3], [8]	—
Highly annoyed (HA)	L_{den}	Prevalence × DW	EC 2002 [3], [8]	—

3 Results

3.1 Noise exposure above threshold

The proportion of the Malmö population exposed above the standard planning thresholds — L_{Aeq} > 55 dB, L_{den} > 55 dB, and L_{night} > 50 dB — is shown in Table 4 for all main scenarios. Results are based on approximately 349,000 matched population–receiver pairs.

In the Base 2025 scenario, half the population (50.5 %) is exposed to L_{den} above 55 dB, with 26.2 % exceeding the L_{Aeq} threshold and 26.5 % the L_{night} threshold. BAU 2040 shows a modest increase across all three metrics, driven by projected traffic growth. The traffic management scenarios (TROMP 2040 and CTZ 2040) reduce exceedances relative to BAU 2040, but only marginally compared to the Base level; CTZ 2040 achieves the greater reduction of the two, bringing L_{den} exceedance slightly below the Base level. The Barriers 2040 scenario produces a more consistent reduction across all three metrics. The most striking result is the Tyre −3 dB scenario, which reduces L_{den} exceedance from 53.2 % under BAU 2040 to 39.1 %, and L_{night} exceedance from 28.8 % to 17.3 %, demonstrating the potential impact of quieter tyres relative to any of the traffic or infrastructure measures.

Table 4. Population exposed above noise thresholds by scenario.

Scenario	L_{Aeq} > 55 dB	L_{den} > 55 dB	L_{night} > 50 dB
Base	91,400 (26.2 %)	176,200 (50.5 %)	92,500 (26.5 %)
BAU 2040	99,100 (28.4 %)	185,400 (53.2 %)	100,400 (28.8 %)
TROMP 2040	91,500 (26.3 %)	177,400 (50.9 %)	92,300 (26.5 %)
CTZ 2040	88,200 (25.3 %)	173,000 (49.6 %)	91,200 (26.2 %)
Barriers 2040	86,200 (24.7 %)	168,600 (48.4 %)	86,700 (24.9 %)
Tyre −3 dB	59,200 (17.0 %)	136,400 (39.1 %)	60,300 (17.3 %)

3.2 Health impact – DALY

Under the BAU 2040 scenario, road traffic noise in Malmö is estimated to cause 2,340 DALYs per year (6.5 per 1,000 population, adjusted for projected 2040 population). The distribution of burden across health endpoints is shown in Figure 1. Sleep disturbance is the dominant component, accounting for 48 % of total DALY, followed by annoyance (23 %). Cardiovascular disease (IHD, stroke, and hypertension combined) contributes the remaining 29 %, reflecting the higher disability weights and disease rates associated with these endpoints relative to their exposed fraction. The Base 2025 scenario yields 2,170 DALY (6.2 per 1,000), meaning that projected traffic and population growth alone adds approximately 170 DALY by 2040. Table 5 shows the total DALY and reduction relative to BAU 2040 for each scenario.

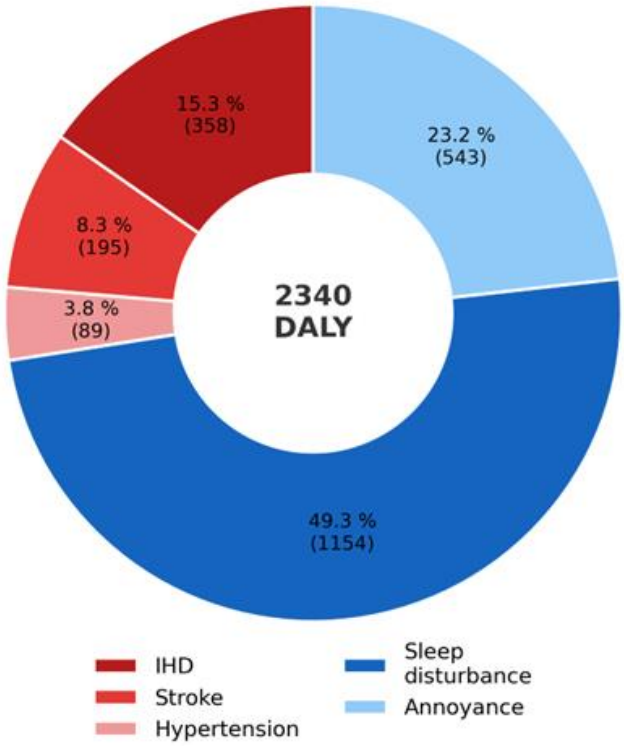

Figure 1: DALY components for the business as usual scenario (BAU 2040).

Table 5. Estimated annual DALY from road traffic noise by scenario, adjusted for projected 2040 population. Change is relative to BAU 2040.

Scenario	DALY (adj.)	Per 1,000 pop.	Change vs BAU 2040
Base 2025	2,170	6.2	-170
BAU 2040	2,340	6.5	—
TROMP 2040	2,240	6.2	-110
CTZ 2040	2,210	6.2	-140
Barriers 2040	2,170	6.1	-170
Tyre −3 dB	1,790	5.0	-550

To support spatial interpretation of the results, per-person DALY contributions were aggregated to a 50×50 m grid and then smoothed with a Gaussian kernel with a bandwith of $\sigma = 100$ m. The smoothing redistributes values from each cell to its neighbours in proportion to the Gaussian weight, producing a continuous surface without sharp grid boundaries. Because the kernel is applied symmetrically across all cells, the city-wide sum is preserved to within 0.1 % (edge diffusion loss); each pixel in the resulting raster therefore represents a genuine DALY density in units of DALY per km², and integrating any sub-area of the map gives the total attributable burden for that area. The difference maps show the change in DALY density relative to BAU 2040, using a colour scale that runs from white (no change) through yellow and orange to red, where red corresponds to a reduction of 60 DALY per km²; cells showing no meaningful change remain uncoloured. This scale is common across the difference maps in Figure 2 and 3 to allow direct visual comparison between scenarios. The background map is obtained from Lantmäteriet (open data 2026).

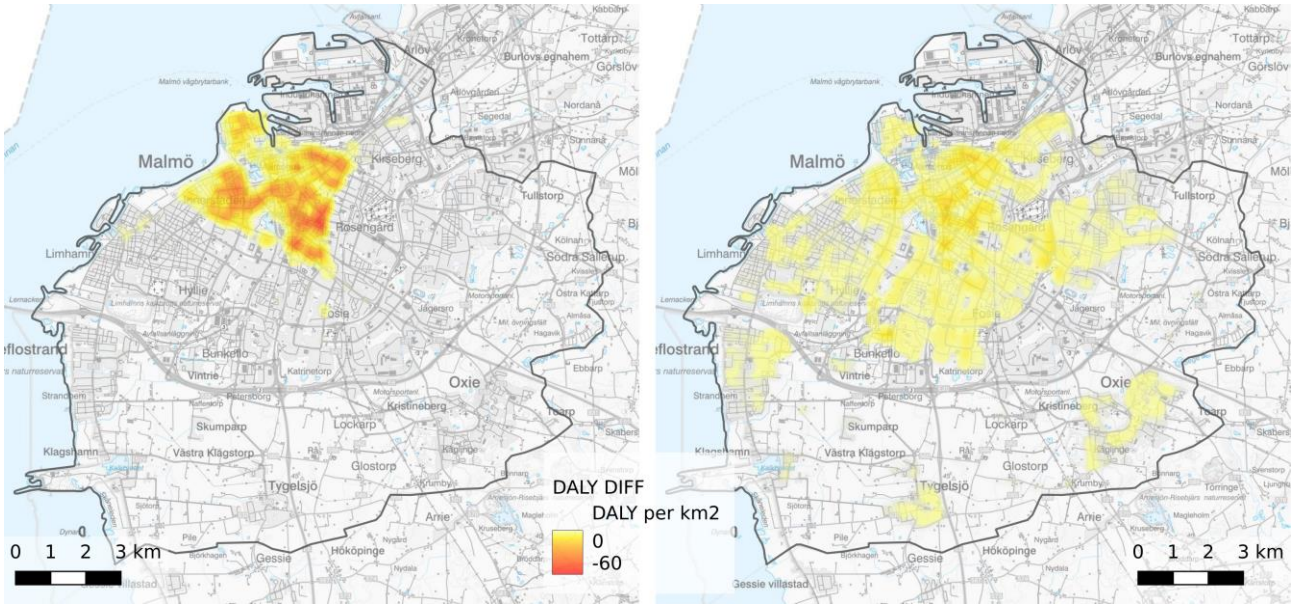

Figure 2: DALY difference map for CTZ (left) and TROMP (right) vs BAU 2040. No colour is zero and red corresponds to a reduction of 60 DALY per km^2.

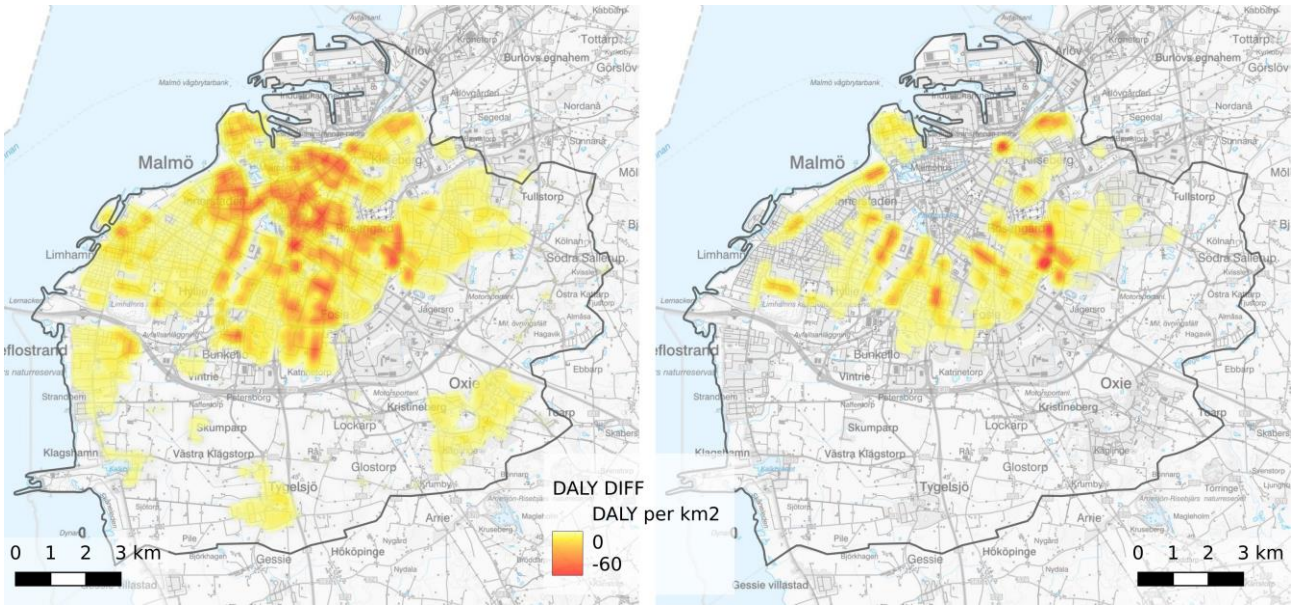

Figure 3: DALY difference map for Tyre –3 dB (left) and Barriers (right) vs BAU 2040. No colour is zero and red corresponds to a reduction of 60 DALY per km^2.

The histogram showing the exposure in 5 dB steps is shown i Figure 4. Here it is clearly visible that the population is redistributed towards lower exposure for the noise reduction scenarios. It is also evident that the traffic scenarios (TROMP and CTZ) have a larger relative impact compared to BAU 2040 for the high exposure categories.

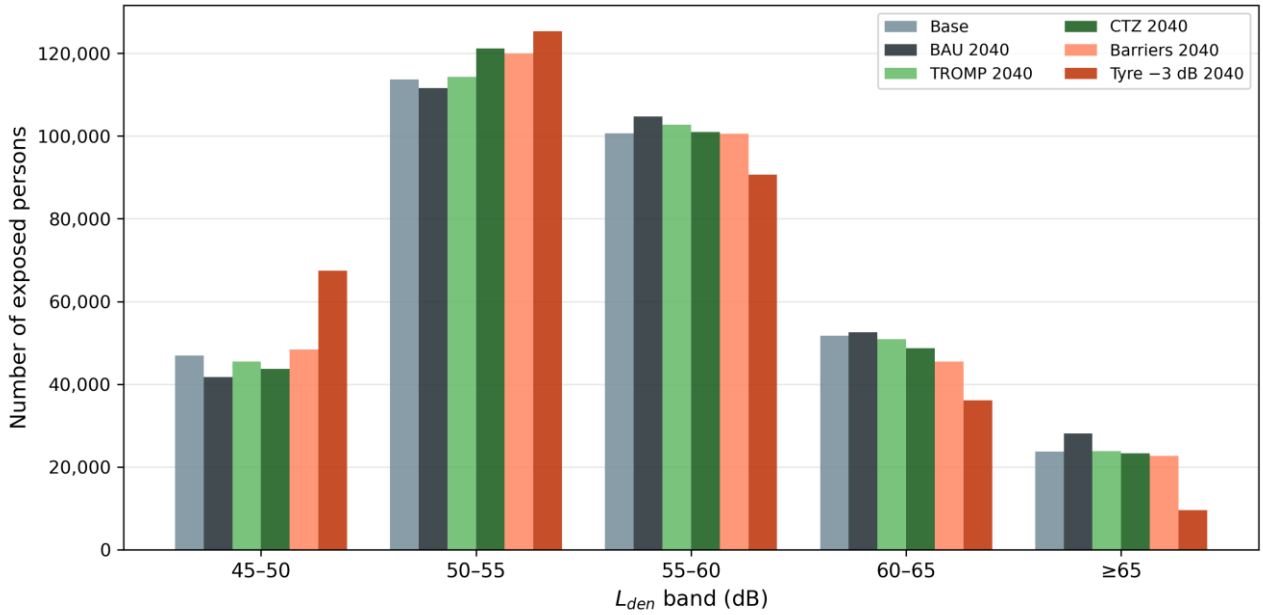

Figure 4: Histogram of number of exposed in 5 dB L_{den} bands for the scenarios.

4 Discussion

The spatial DALY maps reveal that noise burden is concentrated along the major arterial roads and motorway corridors threading through residential areas, with the highest per-km² values consistently found where high-traffic routes run close to dense housing. The difference maps — each showing DALY change relative to BAU 2040 — make the effect of each strategy clearly legible in geographic terms.

TROMP 2040 and CTZ 2040 each produce modest but spatially coherent reductions. The TROMP scenario redistributes heavy vehicles away from certain urban corridors, and the benefit is visible as narrow bands of reduced burden along those routes; areas that receive redirected traffic show little or no improvement, or a marginal increase. The CTZ scenario, through speed reductions across a broader zone of the city, yields a more diffuse pattern of benefit extending beyond the immediate road edge — consistent with the strong sensitivity of tyre–road noise to vehicle speed. Critically, neither of these interventions was only designed primarily as a noise measure. Traffic redistribution and urban speed reduction are driven by emissions reduction, road safety, and liveability objectives; the noise co-benefit is therefore essentially free. Cities pursuing these strategies for climate or sustainability reasons simultaneously reduce noise exposure without any additional cost or dedicated noise policy instrument. This win-win character strengthens the case for such measures even where the noise reduction in isolation would not reach the threshold conventionally required to justify investment.

The acoustically targeted scenarios — barriers and quieter tyres — deliver substantially larger reductions. The Barriers 2040 scenario, representing a technically feasible, but neither legally nor economically realistic, programme of noise barriers along the most exposed corridors, matches the total DALY of the Base 2025 scenario, effectively cancelling out the additional burden from projected traffic and population growth. The Tyre −3 dB scenario goes further still: a city-wide reduction in tyre–road noise of 3 dB does not merely offset growth but returns the population to a meaningfully better situation than today, reducing DALY by approximately 550 relative to BAU 2040 and bringing the total below the Base 2025 level by around 380 DALY. This underlines the singular leverage of tyre noise, which affects the entire road network simultaneously and disproportionately benefits the large share of the population exposed in the 50–65 dB range where prevalence functions and dose–response relationships are steepest. Unlike barriers, which are expensive and spatially constrained, tyre noise regulation operates independently of urban form or road infrastructure and scales automatically with fleet replacement.

Several extensions of this analysis are planned. The −3 dB tyre scenario used here is a simplified first estimate; a more physically grounded scenario based on the tyre noise performance distribution of vehicles currently entering the market is under development. Preliminary indications suggest the overall DALY impact will be similar in magnitude, but the spatial pattern may differ as the benefit distribution across speed classes changes. A second priority is the assessment of combined scenarios — for example, barriers together with CTZ speed reductions, or a tyre regulation applied on top of a TROMP-style network intervention — in order to quantify whether the effects of individual measures are additive or exhibit saturation. A low-noise pavement scenario is also planned, as surface dressing renewals represent a recurring municipal expenditure where a quieter specification could be chosen at modest additional cost. Finally, the current analysis is restricted to residential exposure. Extending the framework to outdoor spaces — parks, school yards, and other public areas used for rest and recreation — would broaden the health perspective and is of direct relevance to urban planning decisions where quiet areas are a recognised asset under the Environmental Noise Directive.

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