Health impact assessment of noise in Rome, Italy

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ABSTRACT:

Our objective was to estimate the exposure levels and evaluate the health impact of road traffic noise on residents in Rome focusing on non-accidental mortality, hypertension, acute coronary events incidence, and sleep disturbances. We estimated road traffic noise indicators (LAeq16h, Lden, Lnigth) for all the residential addresses in Rome using the acoustic model Sound-Plan7.4 (2009 traffic-flow data). Available exposure-response functions were extrapolated from published meta-analyses. The counterfactual levels used were 55 dB(A) for LAeq16h and Lden, 40 dB(A) for Lnigth. Rome citizens (2,617,165 residents) are exposed to relatively high mean annual-levels of noise, 62.6dB(A) LAeq16h, 60.5 dB(A) Lden and 51.3 dB(A) Lnigth. We estimated 882 (CI 95% 78-1,487) non accidental deaths, 15,458 (CI 95 % 5,277-24,491) hypertension cases, 247 (CI 95 % 129-383) incident coronary events, and 146,744 (CI 95 % 76,187-261,099) sleep disorders attributable to traffic noise. The HIA indicates an important negative impact of noise in Rome. Although a certain overlap between the impact of air pollutants and noise must be clarified, results call for the adoption of interventions to reduce traffic and prevent health effects among residents.

INTRODUCTION

According to United Nation estimates, by 2050, almost 70% of the world's population is projected to be urban. Urban living is often associated with people's well-being as it provides employment, access to goods and services, innovation, and opportunities for cultural and political participation [1]. Nevertheless, urban structure is the main determinant of population exposure to a number of environmental factors. Among several aspects of urban life that may contribute to increased morbidity and premature mortality [2–6], road traffic noise health impacts are a growing concern [7]. The World Health Organization (WHO) identified noise as the second most significant environmental stressor, the first being air pollution [8]. In the European Union, about 56 million people (54%) living in major agglomerations (i.e. >250,000 inhabitants) were exposed to road traffic noise of more than average Lden 55 dB(A) per year [9], which is thought to be risky to health [10].

WHO estimated that in high-income western European countries (population about 340 million people), at least 1 million healthy life-years (disability-adjusted life-years) are lost every year

because of environmental noise [11]. Thus, understanding of environmental and in particular road traffic noise impact is important for public health. According to WHO recommendations day time (7:00-23:00 hr) outdoor noise levels should not exceed equivalent sound pressure levels above 55dB(A) and night time (23:00-6:00 hr) outdoor noise levels should not exceed equivalent sound pressure levels above 40dB(A) [10].

Epidemiological studies showed a number of adverse health effects, both direct and indirect linked to exposure to persistent or high levels of noise [8]. In particular, annoyance [12], sleep disturbance [13], blood pressure, hypertension, [14], ischemic heart disease including fatal myocardial infarction [15] and diabetes mellitus [16] have been related to road traffic exposure. However the association between noise and mortality [4] is still controversial.

The objective of this study was to estimate the exposure levels and evaluate the health impact of road traffic noise on residents in Rome.

METHODS

Rome is the largest Italian city, within Lazio Region, has about 2.6 million residents as 21st October 2011 over an area of 1,285 km². The city has 13,506 census track averaging populated by 2,617,175 residents (47% men and 53% women). The vehicle fleet in 2012 was estimated of over 1,800,000 cars, 400,000 motorcycles and 200,000 other type of vehicles (e.g. bus, trucks, etc.) [17], resulting in a high traffic volume and associated noise and air pollution. We considered road traffic data for all major roads in Rome in 2009. The network dataset covers the major roads, which represent the 56% of the total roads present in the municipality of Rome. About 6,200 km of roads based on about 73,800 road segments are included with an average of 6,856 cars per day. The Geographical Information System software was used to project the traffic network dataset based on World Geodetic System of 1984 with the Universal Transverse Mercator zone 33 North projection (WGS84_UTM33N). Noise levels along building facades were estimate through the acoustic model Sound Plan 7.4, and Lden, LAeq16h, and Lnight were calculated. Each indicators give an A-weighted decibels (dBA) level as expression of the relative loudness of sounds in air as perceived by the human ear.

The health outcomes under study were the number of non-accidental deaths, hypertension, coronary events, and sleep disorders cases attributable to road traffic noise. Table 1 shows the methods used to estimate the impact of road traffic noise on the residents in Rome.

RESULTS

Residents in Rome (2,617,165, at 2011 census) were exposed to relatively high mean annual-levels of road traffic noise: 62.6 dB(A) for LAeq16h, 60.5 dB(A) for Lden and 51.3 dB(A) for Lnigth. Table 2 shows the distribution of residents in Rome according to the different noise indicators. Only 510,761 residents (16.3%) were exposed to road traffic noise of less than average Lden 55 dB(A) per year, while145,827 residents (5.6%) were exposed to Lnight value below 40 dB(A). A total of 735,307 residents (28.1%) were exposed to Lden above 65dB(A) and 92,375 (3.5 %) to Lnight value above 65 dB(A).

Table 3 shows, for each outcome, the exposed population, the estimated number of cases attributable to noise and the attributable fraction. We estimated that exposure to road traffic noise levels above 55 dB(A) were responsible each year of 882 (95%CI 76-1,487) non accidental deaths. A total number of 15,458 (95%CI 5,277-24,491) hypertension cases and of 247 (95%CI 129-383) incident coronary events, and 146,744 (95%CI 62,763-299,250) cases

of sleep disorders were attributable to the non-compliance of the international exposure recommendations.

DISCUSSION

This is the first Health Impact Assessment (HIA) of road traffic noise exposure in such important city in Italy. Our results showed that a large mortality and morbidity burden could be prevented, in terms of impact on health, if international recommendation for road traffic noise would complied with. Other HIA have estimated the impact of road traffic noise on mortality and found comparable results to ours. A recent HIA conducted in Barcelona, with around half as many residents and similar environmental conditions, found that almost 600 deaths could be prevented with the adoption of recommended level of noise [18]. Similarly, a study performed in Madrid estimated almost 470 deaths among elderly people (>65 years) attributable to a theoretical traffic noise exposure decrease by 1 dB(A) [19].

Results on sleep disturbance are of particular interest since it is usually considered the most severe non-auditory effect of environmental noise exposure [11,20]. This because short sleep is associated with obesity, diabetes, hypertension, cardiovascular disease, and all-cause mortality [21]. We estimated 7% of the population highly sleep disturbed from road traffic noise, which is a result in accordance with that found in a study for region of Flanders (Belgium), where the percentage was around 7% as well [22].

Several other studies have been conducted on environmental burden disease associated with transport. Most of them focused also on air pollution with a range of chemical contaminants, physical inactivity, and traffic incidents [23–26]. Particularly interesting here is the simultaneous exposure to air pollution and road noise, both arising from road traffic. It is not yet clear whether the impact of noise on selected pathologies is independent, additive or synergistic to the impact of outdoor air pollution. In terms of public health, and for practical use in health impact assessment, it would be helpful to understand the relative contribution of these different environmental stressors to health outcomes. There may be double-counting of case of morbidity when multiple exposure are related. However, independence of health effects has been demonstrated for noise and air pollution exposure, in particular recent studies have strengthened the evidence base for noise and health, beyond effects on noise annoyance and sleep, to providing indication of convincing health impacts in terms of hypertension, risk of ischemic heart disease and mortality [27].

Since we conducted analyses on census tract level, we assumed an equal exposure for all residents inside a census tract (around 200 residents). In addition, we considered that people spent their daily time in the census tract of residence, while it might be not corresponding to the reality (e.g. they move to other census tracts for work), thus the issue of exposure misclassification cannot be ruled out.

In conclusion, non-compliance of recommended levels of road traffic noise leads to a substantial number of additional deaths and cases of hypertension, coronary disease ad sleep disturbance that could be avoided. Improvements in urban structure are expected in order to reduce traffic in the city and prevent large health effects among residents.

Tables

Table 1. Summary of methods used to estimate the impact of traffic noise: health outcomes, noise range, background rates, concentration response functions, type of evidence, and related references

Health outcome	Age range	Background rates			Concentration-response function	Noise Range	Type of evidence	References
Natural mortality[a]	≥25 yy	-	2015	Regional death register	RR=1.04 (1.00 - 1.07) for LAeq16h>60dB(A) vs <55dB(A)	≥55 dB(A)	Ecological study	Halonen et al. 2015 [4]
Hypertension	35-74 yy	Annual prevalence rate Men: 46.4% Wome: 31.1%	2008-2012	http://www.cuore.iss.it/fattori/img2/centro/pressione.gif	RR=1.021 (95%CI 1.007-1.034) (derived from OR=1.034 (95%CI 1.011-1.056)) for 5dB(A) increase of LAeq16h	45-75 dB(A)	Meta-analysis	Van Kempen and Babisch 2012 [14]
Acute coronary events	≥30 yy	Annual incidence rate (per 100,000) Men: 510.14 Women: 272.49	2000-2010	Estimates in RoLs cohort [28]	OR=1.08 (95%CI 1.04-1.13) for 10dB(A) increase of Lden	52-77 dB(A)	Meta-analysis	Babisch 2014 [15]
High sleep disturbance	≥15 yy	-	-	-	[20.8 – 1.05 Lnight + 0.01486 $(Lnight)^2$] for 5dB(A) increase of Lnight	45-70 dB(A)	Meta-analysis	Miedema and Vos 2007 [13]

a. excluding external causes of death

Table 2. Distribution of residents in Rome according to the noise indicators

	Residents (n=2,617,175)					
	Lden		$LAeq_{16h}$		Lnight	
dB(A)	n	%	n	%	n	%
<=40	18,423	0.7	13,084	0.5	145,827	5.6
(40-45]	47,946	1.8	26,878	1.0	285,528	10.9
(45-50]	120,934	4.6	87,028	3.3	616,223	23.5
(50-55]	323,458	12.4	225,118	8.6	733,025	28.0
(55-60]	628,012	24.0	482,015	18.4	520,717	19.9
(60-65]	743,095	28.4	725,422	27.7	223,480	8.5
>65	735,307	28.1	1,057,630	40.4	92,375	3.5

Table 3. Estimated premature cases of natural mortality, hypertension, acute coronary events and high sleep disturbance preventable under compliance with international exposure recommendations

Health outcome	Age range	Exposed population[b]	Mean exposure dB(A)	Number of cases attributable to noise		Attributable fraction (%)
				N	95% CI	
Natural mortality[a]	≥25 years	1,575,746	62.6	882	(78 - 1,487)	3.3
Hypertension	35-74 years	1,073,654	62.6	15,458	(5,277 - 24,491)	3.3
Acute coronary events	≥30 years	1,125,912	60.5	247	(129 - 383)	4.6
High sleep disturbance	≥15 years	-	51.3	146,744	(76,187 - 261,099)	-

a. excluding external causes of death

b. number of subjects exposed to noise level higher than the conterfactual (Lden and Laeq 16h: 55dB(A))

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