Appendix

The health risks and benefits of cycling in urban environments compared with car use: health impact assessment study

Authors

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1. Case description

1.1 Barcelona

Barcelona has a high population density with 1.6 million people in a space of 101 km^2 (density 15,963 inhabitants/km^2). The city is the centre of one of the largest metropolitan areas in Europe, which includes 164 municipalities and 4.4 million people (density 1,359 inhabitants/km^2). Of the 5.1 billion trips made annually in the Barcelona Metropolitan area, 31% are made by car, 18% by public transport, 45% by walking, and 0.9% by cycling [1]. In Barcelona city, walking is also the dominant mode (about 45% of trips), followed by public transport (one third), while the car accounts for close to 10% of all trips and cycling around 2%. There are 1.1 billions journeys per year, about a third representing work-related trips [2]. Conditions for cycling are ideal most of the year thanks to a mild Mediterranean climate (average temp 17.3 Degrees Celsius, 74 days of rain), and a topography that is favourable in most parts of the city with essentially small differences in altitude (16 metres over sea) except for hills at the edges of the city.

1.2 Bicing

Bicing is the name of the 'public bicycle sharing' program in Barcelona inaugurated in March 2007, with the objectives to improve inter-modality, promote sustainable transport, create a new individual public transport system for citizens, promote the bicycle as a common means of transport, improve air quality and reduce noise pollution. The system is managed by Barcelona Serveis Municipals (B:SM), a public company that oversees several city services, such as underground parking garages, parking areas on streets, bus stations, and the city zoo. Clear Channel provides the maintenance and system enhancements. The program is financed in part by fees collected from on-street vehicle parking and from the annual subscriptions and penalties from the late return of bicycles. The initial investment for setting up the system were 15.9 million € and operating costs are 10.2 millions €/year in 2008 [3] (Appendix-Figure 2).

The system was finalized in July 2009 and now consists of 6000 bicycles which can be parked in 425 Bicing parking stations (appendix-Figure 3) spread fairly homogenously across the city (300 to 400 m separations between station on average), albeit with slightly greater coverage of the flat areas of Barcelona and higher concentrations around major transit stations to promote inter-modality. Each station has between 15 and 30 parking slots to lock the bicycle. The bikes can be taken from, and returned to, any station in the system, making it suitable for one way travel. Usage is reserved to members of the program who pay a 30€ annual fee. Because the system is meant primarily for utilitarian travel, trips are limited to 2 hours with the first 30 minute free of charge and each additional 30 minutes costing 43 cents [4]. Bicing is Barcelona's cheapest public transport service.

In August 2009 Bicing had 182,062 subscribers (11% of the population in Barcelona municipality), with a good spread across professional groups but greatest representation of students (16% of Bicing subscribers) and more than half aged above 30. The legal age for Bicing membership is 16. In 2009 68% of Bicing trips were for commuting to work or school, and 37% combined Bicing with another mode of travel. The mean workday Bicing trip distance was 3.29km, lasting on average 14.1 minutes; average week-end trips were 4.15km lasting 17.8 minutes [5].

During the three-year implementation period of the Bicing system, the city council continued investing in its network of bike lanes, reaching 146.8 kilometres in 2009 (Appendix-Figure 3). Cycling in Barcelona experienced a major boom between 2006 and 2008, with a change from 42 thousand trips on bike per year in 2006 to more than 100 thousand trips in 2008 [2;5](Appendix-Figure 3).

2. Data and Model

2.1 General assumptions on travel behaviour

The health impact model inputs are based on a combination of existing data and assumptions made when data was not available. Table 1 in the main text summarizes the major input data, noting which resulted from assumptions made rather than from directly available data. We also indicate in Appendix-Table 8 the data which required interpretations to derive uncertainty distributions. We summarize here the main assumptions made to derive model inputs.

Amongst the major hypotheses made were the number of people who are thought to have "benefited" from the Bicing program and the average amount of cycling behaviour in the Bicing population. First, we estimated the number of daily Bicing users based on available data reported by the city on the average number of daily Bicing trips (37,669 trips/day). Assuming half of the daily Bicing trips were for a one-way trip (37,669 / 2 = 18,834) each made by a unique individual, and the other half were part of a round trip each made by a different set of unique individuals (18,834 / 2= 9,417), we thus calculated the total number of daily Bicing users (18.834 + 9,417= 28,251). The 50% round trips supposition was justified by Bicing data showing in 2008 a 49% asymmetry between Bicing stations (i.e.49% of the stations bared the same number of drop-offs as pick-ups). We then further assumed that of these Bicing users, 10% were cyclists before Bicing, and 90% began cycling as a result of the Bicing program. We assumed the 25,426 "new" cyclists (28,251 * 0.9) shifted from car travel. We consider these cyclists as the "beneficiaries" of the Bicing program as they are the ones who shifted from a motorized and sedentary mode (the car) to an active mode. We thus assume that the daily average number of trips made by each Bicing cyclist is 1.5. We further assumed in our scenario that the total number of days biking in the year were the 219 working days in the Barcelona working calendar. The average trip distance, 3.29 km, was constructed from the average trip duration reported for Bicing in 2008 on week days (14.1 minutes), and assuming an average speed of 14 km/h on a bicycle (14.1*14/60 = 3.29 km). Provided an estimated 1.5 average Bicing trip per day (i.e. 4.93km per day), we thus calculated in all on average 1081 km traveled by Bicing per year (219 *1.5*3.29 = 1081). For our population "benefiting" from the Bicing program, we assumed the Bicing trip replaced the same amount of travel (number of trips and distance) previously made by car. The equivalent time of travel by car that the Bicing trip replaced was calculated based on the average car speed in Barcelona, 23.5km/hr, reported by the Barcelona Municipality [2] (3.29 * 60/23.5 = 8.4 min).

We conducted a sensitivity analysis in which we developed alternative mode shift scenarios, which we describe in Appendix section 3.

2.2 Air pollution model

The detailed modelling framework for air pollution mortality impacts of exposure in the Bicing population is shown in Appendix-Figure 4. The approach, as in de Hartog et al [6], is to adjust the RR for air pollution exposure found in the literature not only to a change in air pollution exposure as would classically be done in a air pollution risk assessment, but to a change in the inhaled dose of air pollutants. The steps thus first involve estimating incremental inhalation dose of the pollutants while cycling compared to driving, accounting for the different exposure concentration as well as for increased inhalation rate while cycling. To normalize this measure of incremental inhalation dose to an equivalent incremental exposure concentration, we estimate total daily inhaled dose for cyclists and car occupants and apply the ratio of cyclist to car inhalation to the yearly mean exposure concentration, as shown in Appendix-Table 2. Specifically in our case, we calculated the total inhaled dose in 24 hours of PM2.5 and BS simplifying daily patterns to three types of activities: sleeping, resting, and in travel (either in a car or on a bicycle). We assumed sleeping and resting took place at “background” levels of exposure concentration, while car and bike travel concentrations were specific to these microenvironments, as measured in Barcelona[7] and summarized in Appendix-Table 3. Pollutant concentrations used when sleeping and resting (i.e. “background”) were based on annual average concentrations reported by fixed monitors in Barcelona. The car and Bicing activity durations were the average daily duration calculated above (12.6 minutes and 21 minutes, respectively), we then assumed 8 hours of sleep and the rest of the day (to reach 24 hours total) at rest. We combined the two to estimate yearly inhalations before and after Bicing for the population that shifted modes. We derived the energy expenditure levels for these different activities from Ainsworth’s compendium of physical activity [8] and calculated a probability distribution of inhalation rates for each for a population distribution of age, gender and weight, as in de Nazelle et al [9]. Resulting total inhaled dose are shown in Appendix- Table 3.

We adjusted the RR_{10} (average adjusted relative risk of all-caused mortality for a $10\mu g/m^3$) reported by Krewski et al[10] for PM2.5 and by Beelen et al [11] for BS with the total inhaled dose of each pollutant to calculate the relative risk between travelling by bicycle and car, (see formula in Appendix-Table 1 and results in Table 2 in main text for PM2.5 and appendix-Table 4 for BS). We also quantified all-cause mortality considering that contaminants from traffic sources are 5 times higher toxicity (see formula in Appendix-Table 1 and results in Appendix-Table 5 and 6).

2.3 Traffic mortality model

Calculation steps of the traffic mortality model are shown in the Appendix-Figure 5. Risk of death from traffic crashes were first expressed as a traffic mortality rate per billion kilometres travelled by bike (4.54) and by car (3.72). Average number of deaths per year from vehicle crashes for car occupants (4.12) and from bike crashes for cyclists (0.55) were divided by the total distance traveled per year by the respective modes in Barcelona. Traffic fatality data was obtained from Barcelona Public Health Agency records and distance travelled by mode. To derive the relative risk function for travel by Bicing compared to the car, we calculated the incremental death toll from yearly distance travelled by Bicing (0.2) compared to equivalent death toll for car travel (0.17), and applied the classic formula for relative risk (incidence in the exposed / incidents of a non-exposed) as shown in Appendix-Table 1.

2.4 Physical activity model

The physical activity- associated mortality impact model of the Bicing program is shown in Appendix-Figure 6. As in the HEAT for cycling tool, we adjusted the RR from the Andersen et al[12] study of bike commuting mortality benefits applying a ratio of average distance travelled by cyclists in Bicing per year (1081 km/year) to the distance travelled by cyclists in Copenhagen where the Andersen study was conducted (1512 km/year), as detailed in Appendix-Table 1.

2.5 Mortality

Once mortality RR functions from our three pathways were derived specifically for our Bicing population as explained in previous sections, we quantified attributable all-cause mortality in a classic risk assessment method [13]. Main calculation steps are described in Appendix-Table 2. Expected mortality in the Bicing population is calculated from all-cause mortality rate in the region of Barcelona applied to the age group distribution of the Bicing population between 16 and 64 years old. From the RR we get the attributable fraction among the exposed (AF_{exp}), identifying the percentage of mortality due to exposure, in this case air pollution, physical activity and traffic accidents in the Bicing population who shifted from driving. Knowing the expected deaths in the Bicing population and AF_{exp}, we can quantify the number of deaths for each pathway. We then sum the attributable deaths from the three exposure pathways to obtain total mortality outcomes of the Bicing program.

We assumed for our main analysis that the Bicing population had the same age distribution as the general population in Barcelona for the 16 to 64 age range, and performed sensitivity analyses assuming either a younger or an older population group, as explained Section 3.

2.6 CO_2 emissions

CO_2 emissions were calculated based on the characteristics of the vehicles fleet circulating in Barcelona, considering the type of fuel used (diesel or petrol) and engine efficiency. We used CO_2 emission factors (per litre of fuel) estimated by the Catalan Office Climate Change for the region of Cataluña (of which Barcelona is the capital). As in the previous quantifications, we assumed that 90% of all journeys made in Bicing replace car trips. The steps used for this calculation are presented in Appendix-Table 7.

3. Sensitivity and uncertainty analysis

Sensitivity analyses were done in different phases. First in a systematic approach we identified 15 input variables most important in driving the results and tested for each the impacts on our final outcome of variations along reasonable ranges of uncertainty distributions. To select these 15 input variables, we performed a preliminary sensitivity analysis varying along the same percentage of uncertainty all input variables present in the model. We identified the input variables most correlated with the model total mortality estimates using rank-order correlation (rank-order use the Spearman's rank correlation coefficient between the distributions, to measure the dependence between the two distributions). We then constructed more specific uncertainty distributions for the 15 most influential variables, depending on the type of information available (a summary of ranges used is shown in Appendix-Table 8). The ranges of mortality estimates resulting from variations along these uncertainty distributions are shown in the main text Figure 1.

We performed additional sensitivity analyses based on alternative scenarios of mode shifts and age distribution, considering only physical activity health benefits, since this was shown to be the main driver of our results. We could not find reliable data on mode shifts, and based the analysis on a non-verifiable source reported in a recently released UN report[14] We thus assumed in this scenario that 10% of Bicing users shifted from car use, 60% from public transport, and 30% from walking. Further, to produce a more realistic scheme, we assumed that those who shifted from walking did so for a 2 km daily commute (and replaced 2 km of daily walking with 2 km cycling). We then used a 6.2 km daily commute for those who shifted from public transport or private vehicle, to keep the same average total commute travel as in our main analysis (4.93 km per day). In addition, we assumed that former public transport users walked for 10 minutes (1.25 km/day) as part of their daily commute. To calculate mortality impacts of Bicing including walking at baseline for pedestrians and public transport users, we first calculated mortality benefits associated with walking vs. no physical activity (as in driving), and then compared this value to the mortality benefits of cycling vs. no activity (i.e. driving). We show calculation steps in Appendix-Table 9. We used the RR function developed by the WHO's "HEAT for walking"[15], adjusting it for the 2 km walk commute and 10 minute walk of the public transport commute, as in the derivation for the cycling RR function in our main analysis (Appendix-Table 1). Specifically, "HEAT for walking" reports a RR function of 0.78 associated with 203 minutes of walking per week, and we derive a RR of 0.89 for a 2 km commute and a RR of 0.93 for 10 minutes of walking (as part of public transport). We also estimate in Appendix-Table 9 a 5 minute walk instead of 10. Columns 4 to 9 of Appendix-Table 9 show the number of deaths saved in each category of per cent mode shift (90%, 70%, 60%, 50%, 30% and 10%). Only numbers highlighted in bold are used in the present analysis, but others are left as additional information of interest to provide indications of potential changes in outcomes from alternative mode shift scenarios. Specifically, to spell out the calculation: i) at baseline (i.e. before Bicing), 60% of our population takes public transport, which translated to 2.55 lives saved compared to if they were driving, and 30% walk, corresponding to 2.14 lives saved compared to driving; thus 4.69 lives are avoided at baseline; ii) after the mode shift to Bicing, 70% are now biking 6.2km, leading to 13.62 avoided deaths (or 11.67+1.95 from PT and car respectively), and 30% are biking 2km and thus avoiding 1.53 deaths compared to if they were driving; total lives saved in this scenario is thus 15.15; iii) we now calculate the difference between the Bicing scenario and the baseline scenario (15.15-4.69), and find 10.46 deaths avoided due to mode shifts to Bicing.

For the age distribution analysis, we developed a younger population scenario assuming a 33 year average, based on a newspaper reporting such an average age in the Bicing population; we were not able to verify this source, however. To create this younger population scenario, we use a similar distribution to the one reported in the Spanish barometer of bicycle[16]**,** trying to emulate the distribution of cyclists from Spain, with the aim of obtaining the average age of 33. The full distribution is illustrated in Appendix-Figure 9 and Appendix-Table 10. The older population scenario assumed a 48 year average age, and a gradual increase of 2% for each 5-year age group starting with 1% Bicing users aged 16 to 19 years, up to 65 years, as shown in Appendix-Table 10 and Appendix-Figure 10. In this scenario most of users were above age 40 (75%). We found that the younger age scenario resulted in 7.43 deaths avoided, while 20.55 deaths were found to be avoided in the older population scenario.

Tables and figures

Table 1. Relative risk formulas for each model

Relative Risk (RR)	
Physical Activity	$1-\left(\frac{\text{Distance cycled in Barcelona}}{\text{Distance cycled in Copenhagen}} * (1-0.72)\right)$ [a]
Traffic accidents	$\frac{\text{Deaths in the population} + (\text{Deaths in Bike} - \text{Deaths in car})}{\text{Deaths in population}}$ [b]
Air Pollution	$\text{Exp}[\ \text{Ln}(RR_{10}) * \left(\frac{\text{Equivalent change}}{10}\right)\ ]$ [c]
Air pollution * 5	$\text{Exp}[\ 5 * (\text{Ln}(RR_{10})) * \left(\frac{\text{Equivalent change}}{10}\right)\ ]$ [c]

[a] 0.72 according with the relative risk of death for biking to work reported by Andersen et al in 2000.
[b] Used deaths per year; deaths in bike and car according with deaths per billion km travelled and distance travelled in each mode.
[c] This RR was calculated for each pollutant, with equivalent change and RR_{10} specific for PM2.5 or BS; RR_{10}= average adjusted relative risk of all-caused mortality for a 10µg/m^3 change of pollutant.

Table 2. General formulas

Attributable Fraction among exposed	$AF_{exp} = \frac{(RR-1)}{RR}$
Mortality rate in Bicing population	Mortality rate in Barcelona region * Bicing population
Mortality due to exposure	Mortality rate in Bicing population * AF_{exp}
Deaths per billion kilometres travelled [a]	(Number of fatalities [b] * Kilometres travelled per year) * 1 billon
Inhaled dose (µg/day) [c]	Minute ventilation(m^3/h) * Duration(h/day) * Concentration(µg/m^3)
Total dose (µg/day) [c]	Inhaled dose during Sleep + Rest + Transport
Equivalent change (µg/m^3) [c]	$\left(\left(\frac{\text{Total dose in bike}}{\text{Total dose in car}}\right) - 1\right)$ * Mean concentration of pollutant

[a] This formula was calculated for each mode of transport.
[b] The number of fatalities used was the annual average of fatalities per mode between 2002-2010 in Barcelona.
[c] The input data in this formula was weighted by the 365 days a year and calculated for each pollutant

Table 3. Air pollution variables

	Concentration (μg/m³)		Minute ventilation (m^3/hr) [a]	Activity duration (hrs)	Inhaled Dose during each activity on a day (μg)		Total inhaled dose in one day (μg)[c]	
	PM2.5*	BS*			PM2.5*	BS*	PM2.5*	BS*
Sleep	19	1.7	0.27	8	41	3.6		
Rest	19	1.7	0.61	15 [b]	173	15.5		
Car	46.2	18	0.61	0.21	5.9	2.3	237	22
Cycle	29.5	8.3	2.22	0.35	23	6.5	245	24

*PM2.5: Particulate matter les than 2.5 micrometers; BS: Black Smoke.
[a] Minute ventilation in bike is calculated using a random population distribution and algorithms developed by the EPA (Johnson 2002; de Nazelle et al. 2009) from average METs measured for [Bike, car, rest] = [6, 2, 1]. Uncertainty based on data.
[b] Number of hours remaining to reach 24 hours in a day (ie. to the 15hr add 0.79hr for the car scenario and 0.65hr for the bike scenario).
[c] **Average inhaled dose per day as a function of car and bike life styles, assuming travel on 219 work days per year and 146 no travel days**.

Table 4. Mortality considering the effects of Black Smoke

	RR[a]	AF_{exp}[b]	Deaths / year
Traffic injury	1.0007	0.0007	0.03
Air pollution BS [c]	1.0009	0.0008	0.04
Physical Activity	0.80	-0.23	-12.46
Total			**-12.37**

[a] RR: Relative Risk of death in bicycle vs car; [b] AF_{exp}: attributable fraction among exposed; [c] BS: Black Smoke.

Table 5. Mortality of PM2.5, considering a 5-fold higher toxicity of contaminants from motorized sources

	RR x 5 [a]	AF_{exp} [b]	Deaths / year
Traffic injury	1.0007	0.0007	0.03
Air pollution			
PM2.5[c]	1.013	0.012	0.65
Physical Activity	0.80	-0.23	-12.46
Total			**-11.77**

[a] RR: Relative Risk of death in bicycle vs car, considering a 5-fold higher toxicity of contaminants from motorized sources; [b] AF_{exp} : attributable fraction among exposed; [c] PM 2.5= Particulate Matter of 2.5 micrometers of diameter.

Table 6. Mortality of BS, considering a 5-fold higher toxicity of contaminants from motorized sources

	RR x 5 [a]	AF_{exp} [b]	Deaths / year
Traffic injury	1.000	0.0007	0.03
Air pollution			
BS[c]	1.004	0.004	0.22
Physical Activity	0.80	-0.23	-12.46
Total			**-12.20**

[a] RR: Relative Risk of death in bicycle vs car, considering a 5-fold higher toxicity of contaminants from motorized sources; [b] AF_{exp} : attributable fraction among exposed; [c] BS: Black Smoke.

Table 7. CO_2 assessment, according fuel consumption and car efficiency

Distance replaced by Bicing instead of cars (km/year) [a]
Number of kilometres travelled in Bicing per year * Percentage of vehicles for fuel type in Barcelona
Liters saved by efficiency of vehicle (L/year) [a]
Distance replaced by Bicing (km/year) * Efficiency of vehicles fleet by fuel type (L/100km)
CO_2 saved per year (kg/year) [a]
Liters saved by efficiency of vehicle * CO_2 released by fuel type (kg/L)

[a] Diesel or petro

Table 8. Input variable in Sensitivity analysis

Variable (unit)	Distribution	Mean value	Range [a]	Description
Minute ventilation in Bike (m^3/hr)	Normal	2.22	0.05 – 4.38	Minute ventilation in bike is calculated using a random population distribution and algorithms developed by the EPA (Johnson 2002; de Nazelle et al. 2009) from average METs measured for [Bike, car, rest] = [6, 2, 1]. Uncertainty based on data.
PM2.5 concentration in Bike (µg/m^3)	Normal	29.5	22.89 - 33.86	PM2.5 concentration measured in Barcelona. Uncertainty based on data.
BS concentration in car (µg/m^3)	Normal	18	11.89 – 18.7	BS concentration measured in Barcelona. Uncertainty based on data.
Bicing trip duration (min)*	Triangular	14.1	7.05 – 21.15	Bicing trip duration reported by Barcelona city council in 2008. The uncertainty range (+/- 50%) [b] based on author judgment.
Car speed (km/h)*	Triangular	23.5	11.75 – 35.25	Average car speed reported by Barcelona city council in 2008. The uncertainty range (+/- 50%)[2] based on author judgment.
Number of trips by bicycle per day in BCN*	Triangular	100,840	50,420 – 151,260	Number of trips by bicycle per day reported by Barcelona city council in 2008. The uncertainty range (+/- 50%)[2] based on author judgment.
Trips in Bicing per day	Triangular	37,669	25,506 – 47,069	Trips in Bicing per day reported by Barcelona city council in 2008. Uncertainty range was based on monthly variation of the trips so that minimum values were based on January and maximum to June.
Proportion of round trips in Bicing*	Triangular	0.5	0.25 - 0.75	Proportion of round trips in Bicing derived from the index of asymmetry of all stations Bicing. The uncertainty range (+/- 50%)[b] based on author judgment.
Duration of daily trip (min)	Triangular	21.29	13.05 - 36.21	Duration of daily trip based on mobility survey in the metropolitan area of Barcelona in 2006. Uncertainty range is based

				on differences between the average trip lengths between different purpose of the trip.
RR of BS	Normal	1.05	1.00-1.10	RR per 10 µg/m^3 of increase in Black smoke concentration. Based on Beelen et al 2008.
RR of PM2.5	Normal	1.04	1.03 -1.06	RR per 10 µg/m^3 of increase in PM 2.5. Based on Krewski et al 2009.
Number of days cycled per year	Triangular	219	175 - 365	The average number of days cycled per year is based number of working days in Barcelona (discounting holidays, vacation and weekends according to the official calendar in Spain). The minimum value is based on the school calendar in Spain, and the maximum value includes all days of year.
Proportion cyclist start*	Triangular	0.9	0.45 - 1.0	Proportion cyclist start describes the proportion of cyclists who are new cyclists. The minimum value is – 50%[b]. The maximum value was assumed to be 100% (all users are new cyclists).
Deaths per billion km travelled in bike*	Triangular	4.54	4 - 82	Deaths per billion km travelled in bike were obtained from the cyclists mortality records in Barcelona for the last 9 years (2002-2010). The maximum range is the estimate reported by de Hartog et al, for Spain (10 x 8.2 deaths per billion km travelled in the Netherlands).
RR physical activity in all cause mortality	Normal	0.72	0.57 - 0.91	RR reported by Andersen et al 2000. The same RR values have been used also in HEAT for Cycling project, coordinated by World health Organization (WHO).

[a] For Triangular distribution rage is min-max; for normal distribution 95% confidence interval.
[b] In a case where data did not include any uncertainty distribution, uncertainty was assumed to be +/- 50% around the mean. * Data resulted from assumptions; RR= Relative Risk; METs= Metabolic Equivalent of Task; PM 2.5= Particulate Matter of 2.5 micrometers of diameter; BS= Black Smoke; BCN= Barcelona; CI= confidence Intervals; HEAT= Health Economic Assessment Tool; WHO= World Health Organization.

Table 9. Deaths saved in different shift mode scenarios

Mode of transport	RR[i]	AF exp[j]	Deaths saved per percentage of shift mode vs car* 90%	70%	60%	50%	30%	10%	Scenario without bike vs car*		Difference between scenarios [k]
Walk 2 km[a]	0,89	-0,12	-6,41	-4,99	-4,27	-3,56	**-2,14**	-0,71	60% PT 10 min[d]	**-2,55**	
Walk 4.9 km[b]	0,73	-0,37	-19,30	-15,01	-12,86	-10,72	-6,43	-2,14	10% Car	0	
Walk 6,2 km[c]	0,64	-0,57	-29,49	-22,94	-19,66	-16,38	-9,83	-3,28	30% Walk 2 km	**-2,14**	
PT 10min[d]	0,93	-0,07	-3,83	-2,98	**-2,55**	-2,13	-1,28	-0,43	**Total**	**-4,69**	
PT 5min[e]	0,97	-0,04	-1,85	-1,44	-1,23	-1,03	-0,62	-0,21			
									Scenario with bike vs car*		
Bike 2 km[f]	0,92	-0,09	-4,60	-3,58	-3,07	-2,56	**-1,53**	-0,51	60% Bike 6,2 km	**-11,67**	
Bike 4.9 km[g]	0,80	-0,23	-12,46	-10,14	-8,69	-7,25	-4,35	-1,45	10% Bike 6,2 km	**-1,95**	
Bike 6,2 km[h]	0,75	-0,34	-17,51	-13,62	**-11,67**	-9,73	-5,84	**-1,95**	30% Bike 2 km	**-1,53**	
									Total	**-15,15**	Total deaths saved
											10,46

[*] The car is de reference scenario, with RR=1; [a] people walk 2 km per day; [b] people walk 4.9 km per day; [c] people walk 6.2 km per day; [d] people walk 10 minutes per trip (1.25 km/day) when use public transport; [e] people walk 5 minutes per trip (0.62 km/day) when use public transport; [f] people cycling 2 km per day; [g] people cycling 4.9 km per day; [h]people cycling 6.2 km per day; [i] RR: relative risk (the RR reported for walk and public transport are adjust with the RR=0.78 used for the WHO-HEAT for walking; and the RR reported in bike are adjust for RR=0.72 used in WHO-HEAT for cycling); [j] AFexp: attributable fraction in exposure population; [k] Difference between scenario without bike vs scenario with bike.

Table 10. Bicing age scenarios

	Population distribution		
Age groups	BCN distribution (%)	Young scenario (%)	Older scenario (%)
15-19	6	13	1
20-24	8	15	3
25-29	12	16	5
30-34	14	14	7
35-39	12	12	9
40-44	11	10	11
45-49	10	8	13
50-54	9	6	15
55-59	9	4	17
60-64	8	2	19
Average age	39	33	48
AF exp	-0,23	-0,23	-0,23
Deaths expected [a]	52	31	86
Deaths saved [b]	12,46	7,4	20,5

*BCN: Barcelona; AF_{exp}: attributable fraction among exposed;
[a] Deaths expected in 25,426 persons with age distribution according for each scenario;
[b] Deaths saved related with physical activity vs car scenario.

Figure 1. Model

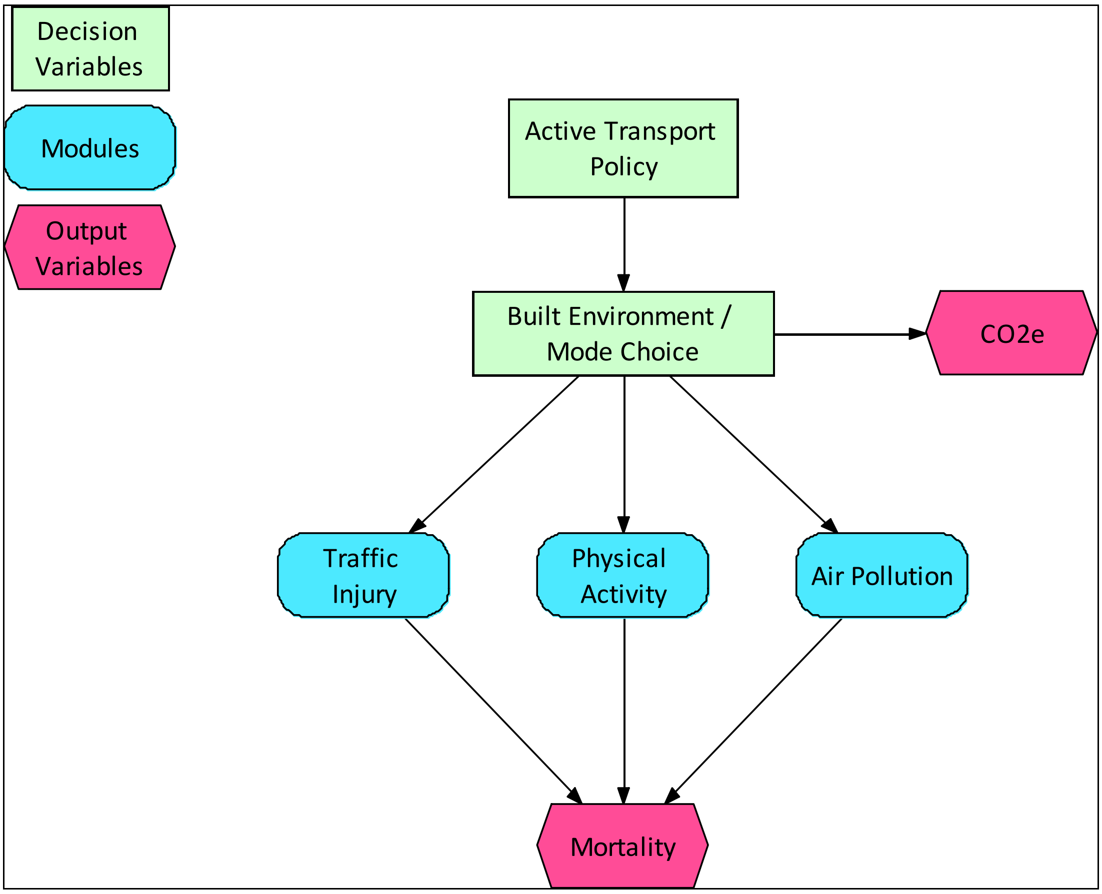


Figure 2. Bicycles used in the Bicing system

Figure 3. Bike use and Bicing evolution

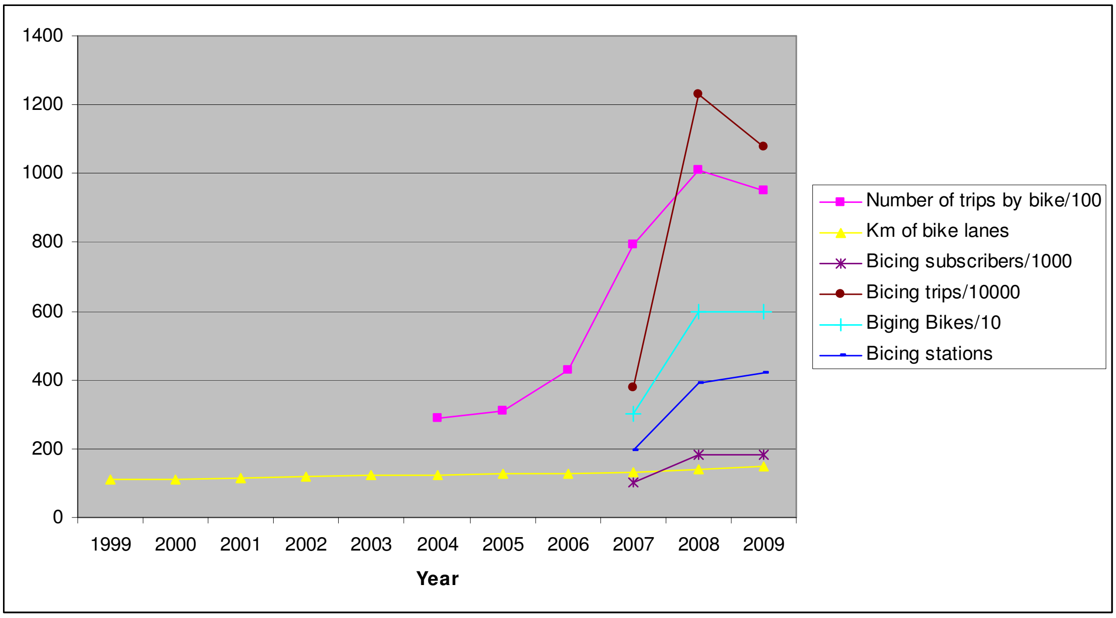
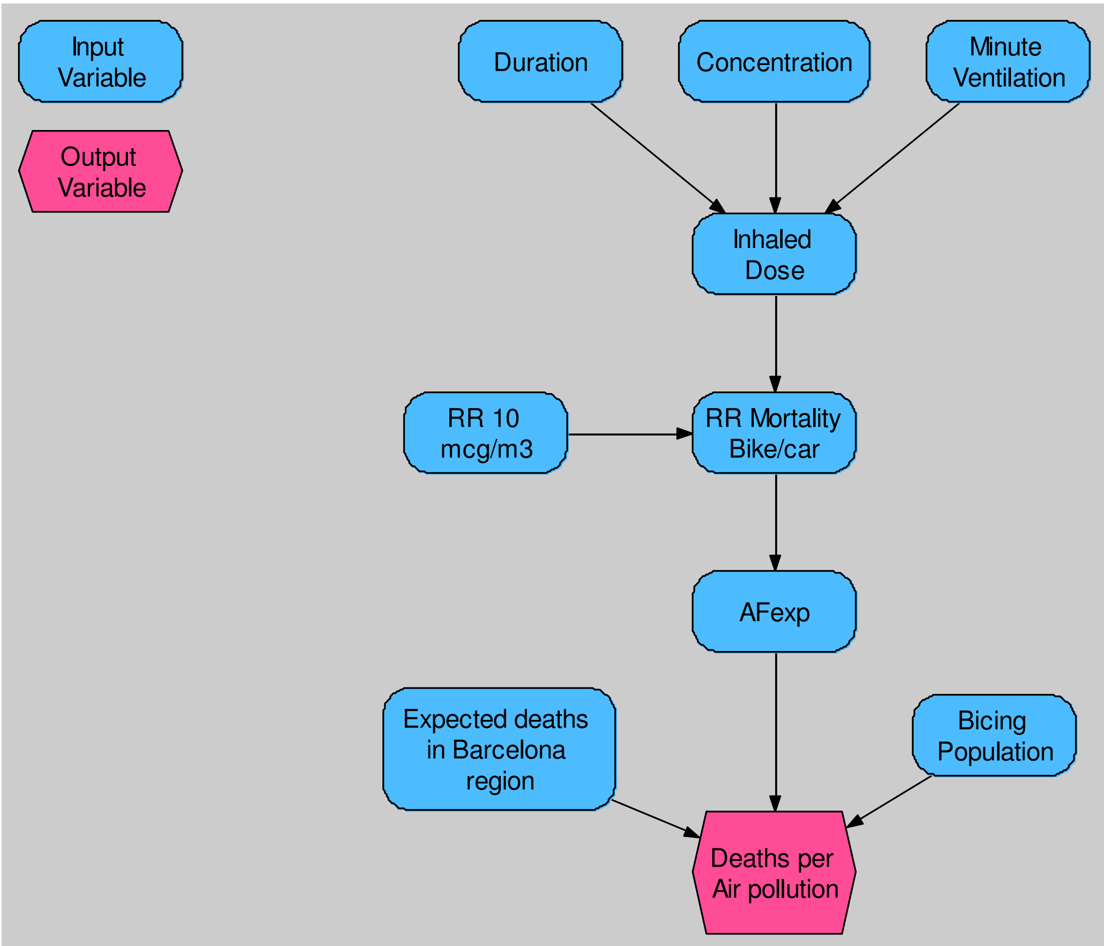
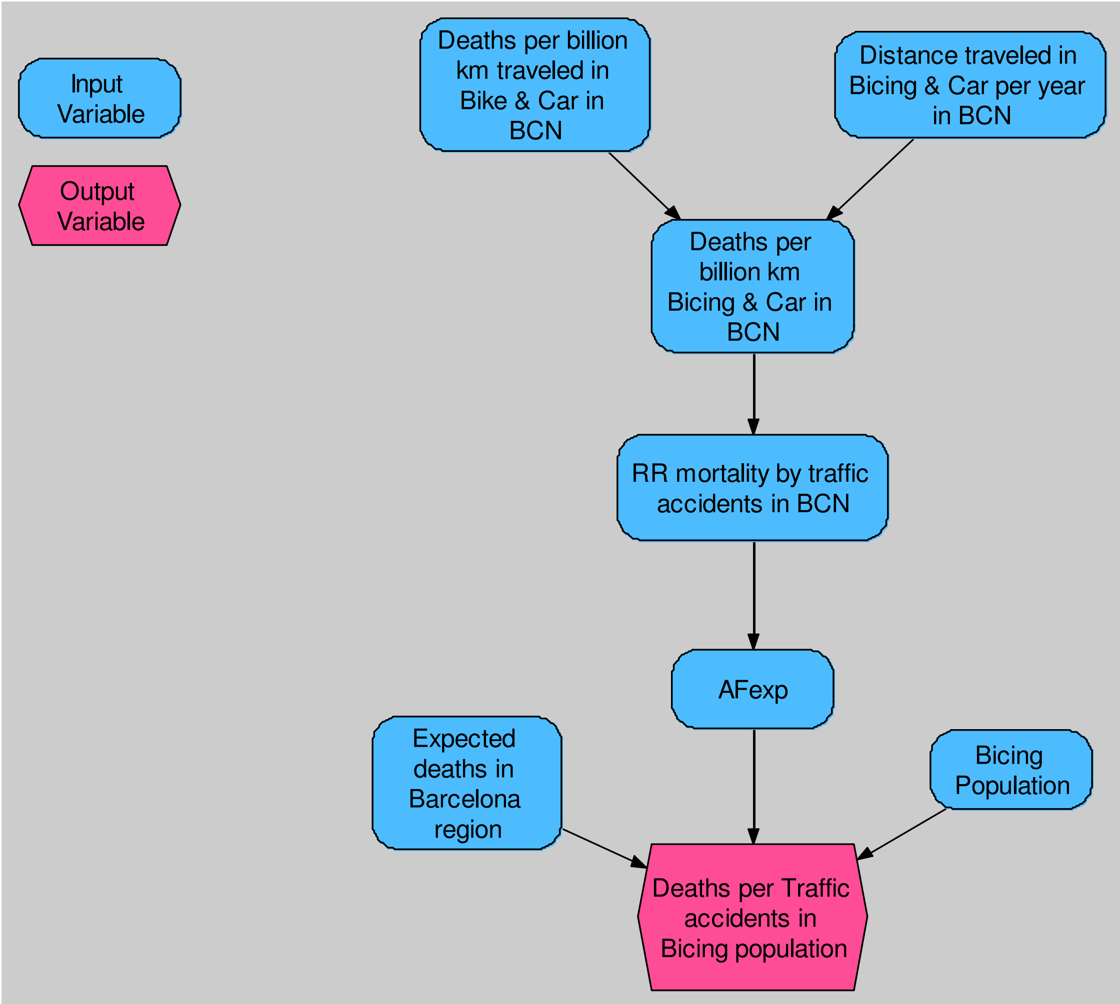


Figure 4. Air Pollution Model



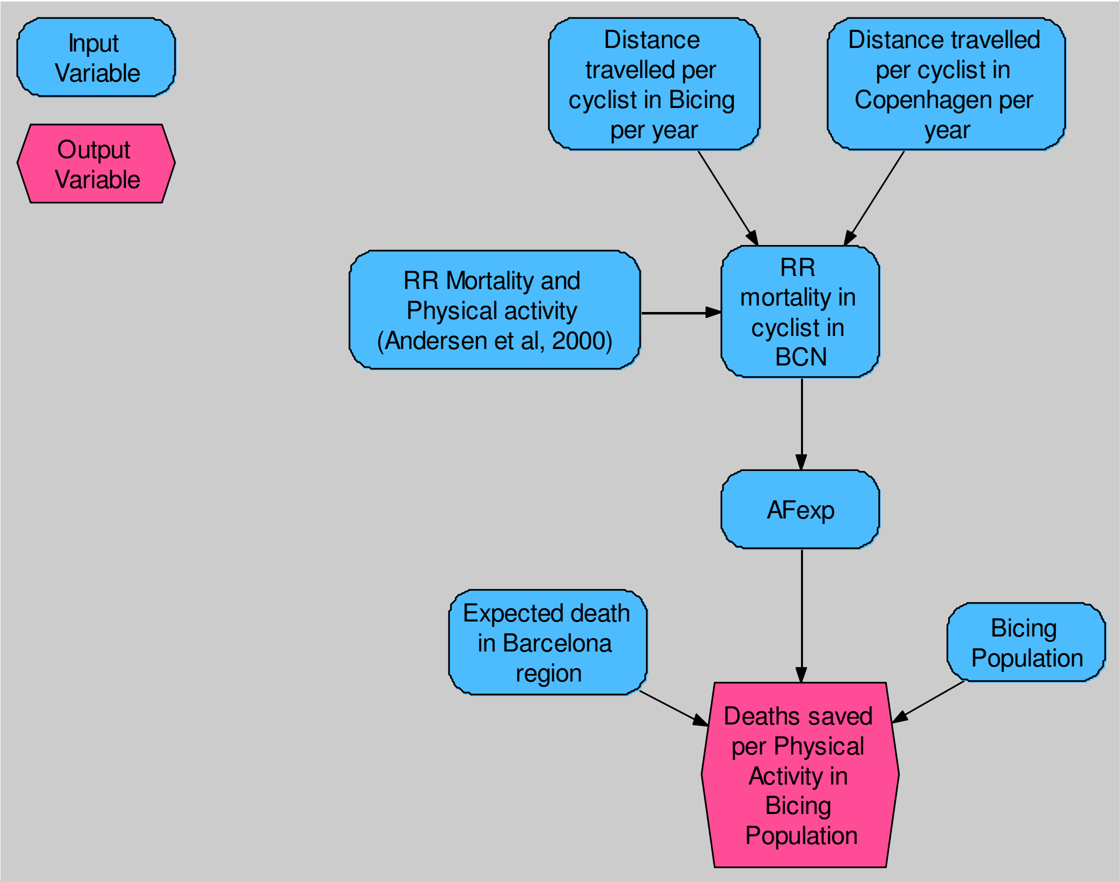
RR: Relative Risk of all-cause mortality.
RR_{10}: average adjusted relative risk of all-caused mortality for a 10µg/m^3 change of pollutant.
AF_{exp}: Attributable fraction among exposed.

Figure 5. Traffic Accidents Model



BCN: Barcelona.
RR: Relative Risk of all-cause mortality.
AF_{exp}: Attributable fraction among exposed.

Figure 6. Physical Activity Model



BCN: Barcelona.
RR: Relative Risk of all-cause mortality.
AF_{exp}: Attributable fraction among exposed.

Figure 7. Sensitivity analysis correlation

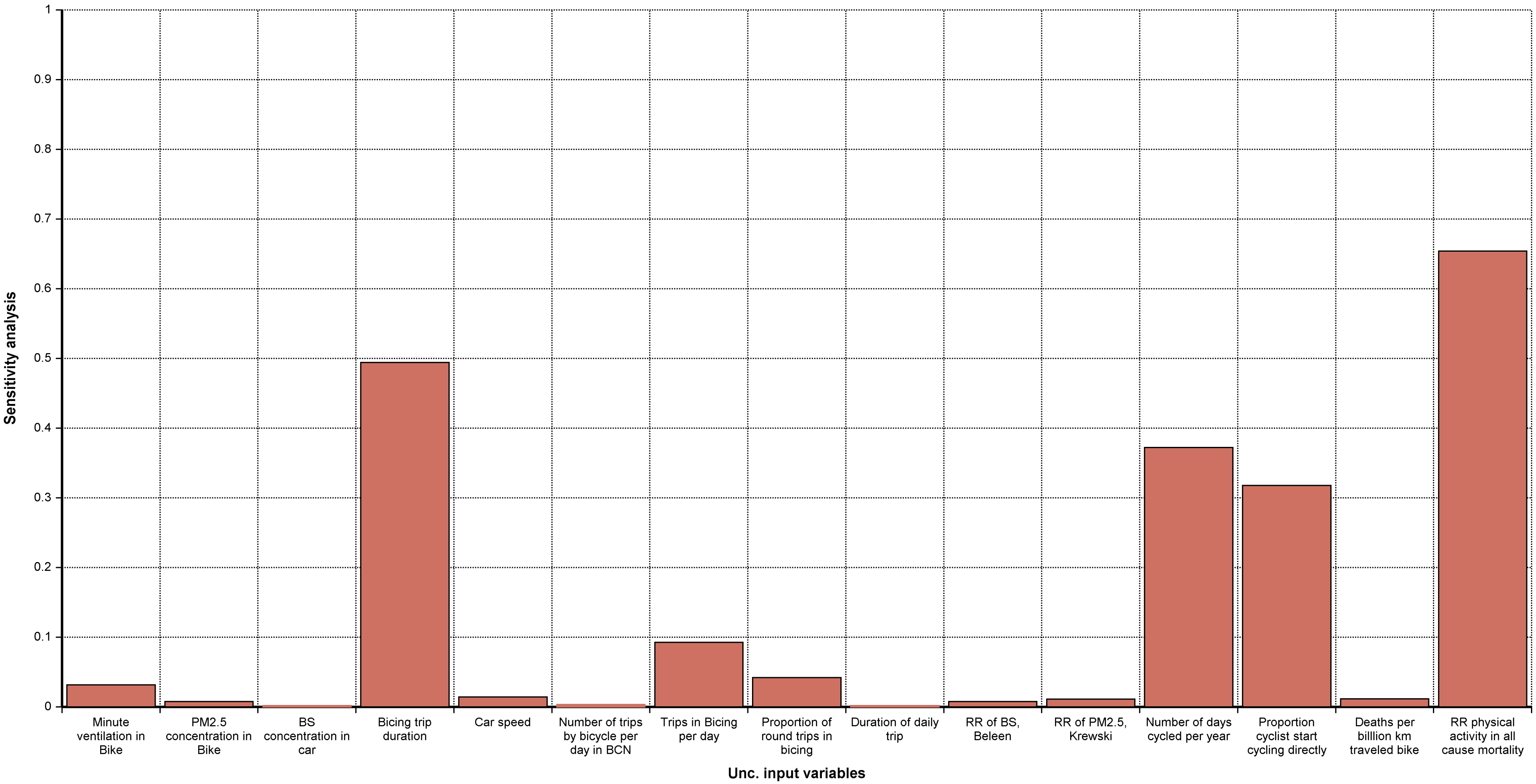
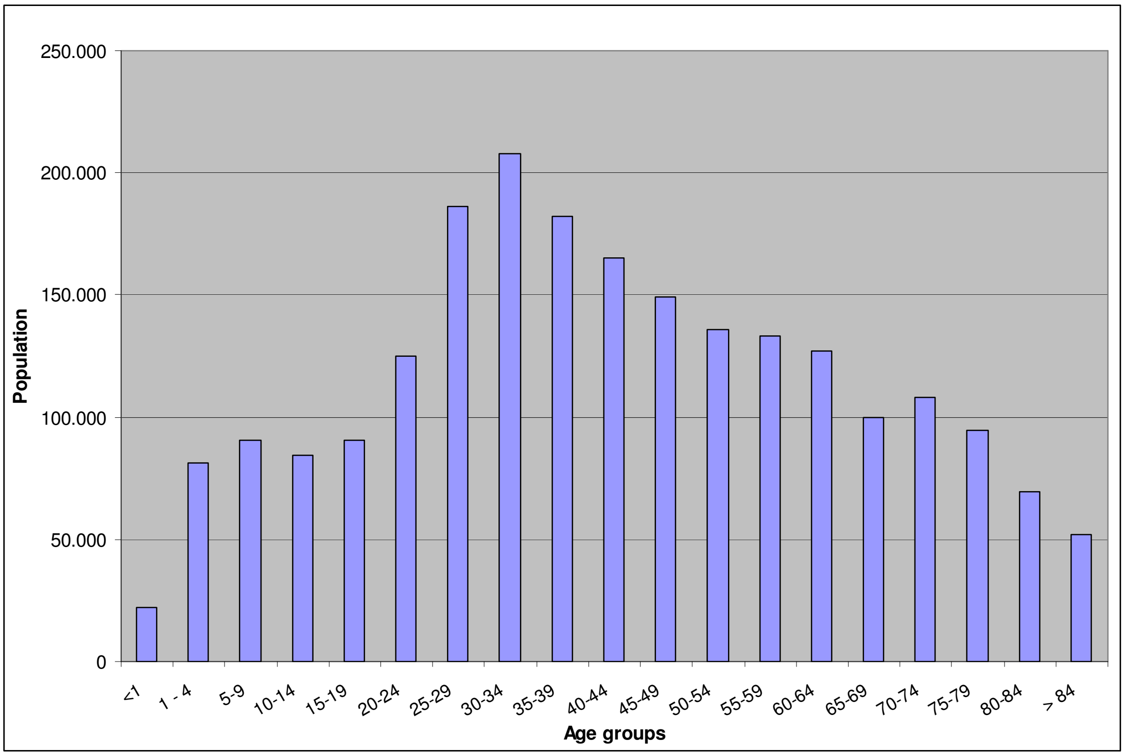


Figure 8. Distribution by age groups of Barcelona population*



* Statistics and information service, Catalan government 2007.

Figure 9. Age distribution in younger Bicing population scenario

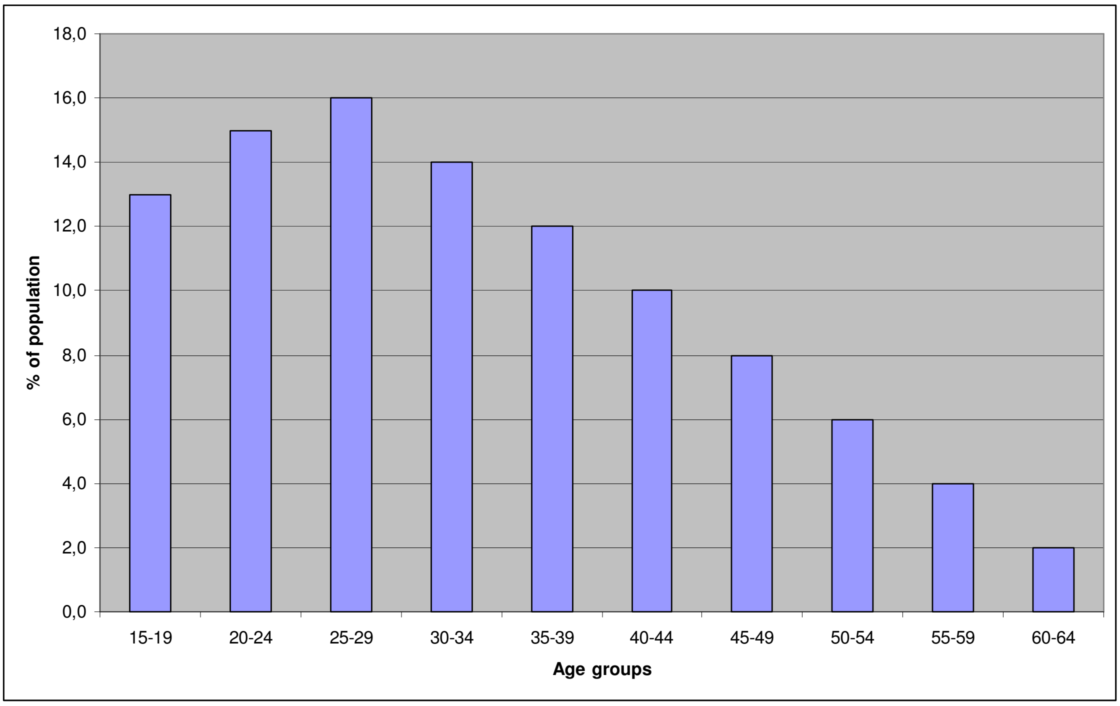
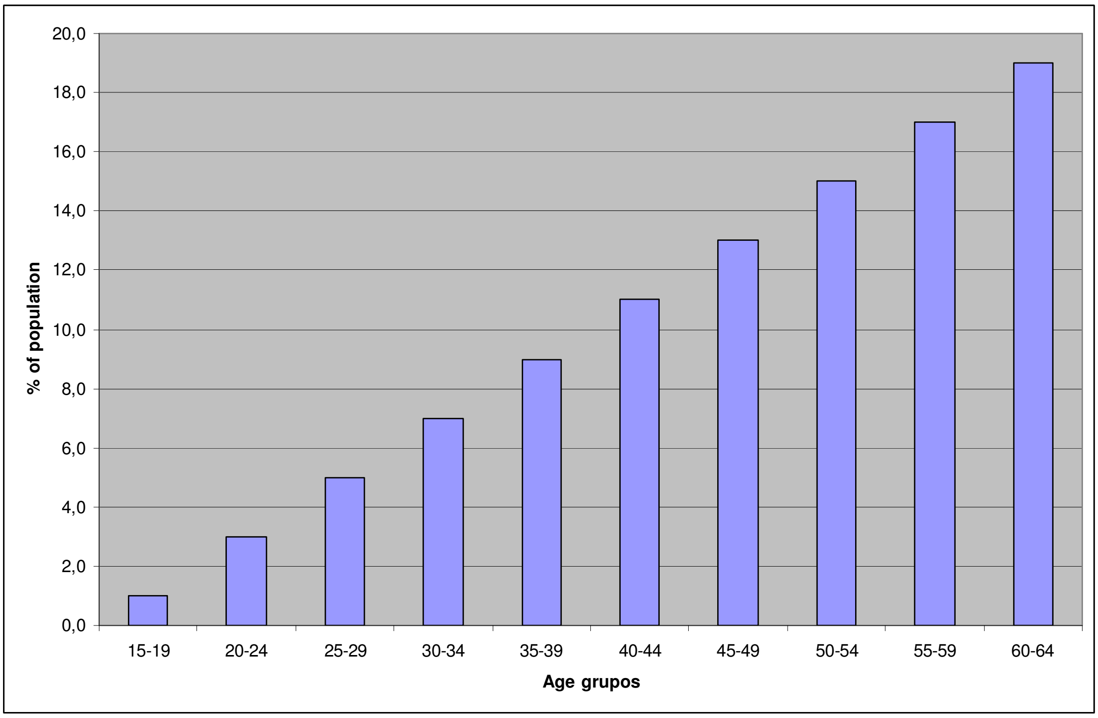


Figure 10. Age distribution in older Bicing population scenario



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