# Supporting Information

# Assessing alcohol consumption through wastewater-based epidemiology: Spain as a case study

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**Table S1.** Description of sampled WWTPs (name, population served and locations/districts covered with main city in bold) and the sampling protocol carried out (location of autosampler, and sampling mode, start time and period).

| Regions | City[a] | WWTP name | Population served by the WWTPs | Method used to estimate the population served[b] | Locations/districts served by the WWTPs | Percentage of the main city covered by the WWTP[c] | Location of autosampler | Sampling mode[d] | Sampling start time | Sampling period |
|---|---|---|---|---|---|---|---|---|---|---|
| Balearic Islands | **Palma de Mallorca** | Palma I | 406,492 | Census 2017 | Palma beach, Sant Jordi, El Pil·lari, Son Sant Joan airport, part of Palma de Mallorca | 100 | After fine screen | T (100 mL/ 15 min) | 10:00 | 10/04/2018-16/04/2018 |
| | | Palma II | 47,961 | Census 2017 | Palma de Mallorca (main part), Marratxí, Esporles, Bunyola and Son Castelló, Can Valero, Son Rosinyol industrial states | | After fine screen | T (100 mL/ 15 min) | 10:00 | 18/04/2018-24/04/2018 |
| Basque Country | **Bilbao** | Galindo | 860,237 | Census 2016 | Abanto-Zierbena, Alontsotegi, Arrigorriaga, Barakaldo, Barrika, Basauri, Berango, Bilbao, Derio, Erandio, Etxebarri, Galdakao, Getxo, Leioa, Lezama, Loiu, Ortuella, Portugalete, Santurtzi, Sestao, Sondika, Sopelana, Trapagaran, Ugao-Miravalles, Urduliz, Zamudio, Zaratamo, Zeberio | 100 | After coarse screens and pumping | T (100mL/ 60 min) | 8:00 | 17/04/2018-23/04/2018 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Castilla-La Mancha | **Toledo** | Estiviel | 79,793 | Average BOD April-May 2018 | Toledo | 100 | After sieving | T (100 mL/ 15 min) | 8:00 | 17/04/2018-23/04/2018 |
| | **Guadalajara** | Guadalajara | 94,755 | Average BOD Jan-April 2018 | Guadalajara | 100 | Before fine screen | T (200 mL/ 60 min) | 10:00 | 02/05/2018-08/05/2018 |
| Catalonia | **Barcelona** | Baix Llobregat | 1,163,154 | Census 2017 | Barcelona, Cervelló, Cornellà de Llobregat, Esplugues de Llobregat, Hospitalet de Llobregat, El Prat de Llobregat, Sant Boi de Llobregat, San Joan Despí, San Just Desvern | 35 | Mechanical bar screens | T (50 mL/ 10min) | 9:00 | 14/03/2018-20/03/2018 |
| | **Lleida** | Lleida | 143,612 | Census 2017 | Lleida , Alpicat | 100 | Before fine screen | T (200 mL/ 60 min) | 6:00 | 07/03/2018-13/03/2018 |
| | **Reus** | Reus | 115,000 | Census 2017 | Reus , Castellvell, Almoster | 100 | After fine screen | F | 20:00 | 17/04/2018-23/04/2018 |
| | **Tarragona** | Tarragona | 142,635 | Census 2017 | Tarragona , La Canonja, Els Pallaresos | 100 | Before fine screen | T (450 mL/ 60 min) | 8:00-9:00 | 17/04/2018-23/04/2018 |
| Community of Madrid | **Madrid** | Madrid-Centre | 727,176 | Average COD for the sampling period | Madrid-Center (Neighborhoods: Chamartín, Tetuán, Moncloa-Aravaca, Chamberí, Centro, Arganzuela, Retiro, Ciudad Lineal, Salamanca, Moratalaz, Puente de Vallecas). | 30 | After sieving | T (400 mL/ 30 min) | 8:00 | 16/05/2018-22/05/2018 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Madrid** | Madrid-North | 227,869 | Average BOD 2016 (with 60 g BOD/d) | Pozuelo y Madrid-North: (Neighborhoods: Chamartín, Tetuán, Moncloa, Aravaca, Fuencarral, El Pardo, Las Rozas, Majadahonda) | | After fine screen | T (100 mL/ 60 min) | 8:00 | 20/06/2018-26/06/2018 |
| | **Móstoles** | El Soto | 187,281 | H x 3.5 (WWTP recomm.) | Móstoles, Alcorcón, Fuenlabrada | 90 | After fine screen | T (100 mL/ 60 min) | 8:00 | 17/05/2018-23/05/2018 |
| Galicia | **Santiago de Compostela** | Silvouta | 136,500 | H x 2.5 (WWTP recomm.) | Santiago de Compostela | 100 | After fine screen | T (150 mL/ 10 min) | 9:00 | 13/03/2018-19/03/2018 |
| Community of Valencia | **Castellón** | Castellón de la Plana | 171,669 | Census 2015 | Castellón | 100 | Before fine screen | T (100 mL/ 15 min) | 8:30 | 11/04/2018-17/04/2018 |
| | **Valencia** | Pinedo I (Valencia-PI) | 527,222 | COD | Valencia (main part) | 100 | After fine screen | T (100 mL/ 60 min) | 8:00 | 10/04/2018-16/04/2018 |
| | **Valencia** | Pinedo II (Valencia-PII) | 788,242 | COD | Albal, Alcàsser, Alfafar, Benetúser, Beniparrell, Burjassot, Catarrojja, Llocnou de la Corona, Massanassa, Mislata, Paiporta, Paterna, Picanya, Picassent, Sedaví, Silla, Torrent, part of Valencia | | After fine screen | T (100 mL/ 60 min) | 8:00 | 10/04/2018-16/04/2018 |
| | **Valencia** | Quart-Benager (Valencia-QB) | 162,249 | COD | Alaquàs, Aldaia, Manises, Mislata, Quart de Poblet, Xirivella | | After fine screen | F | 8:00 | 10/04/2018-16/04/2018 |

[a]Name of the main city served by the WWTPs (some WWTPs receive wastewater from other towns included in the capital metropolitan area). [b]BOD: Biochemical Oxygen Demand; COD: Chemical Oxygen Demand; H: Number of homes connected to the sewage system. WWTP recomm: following WWTP recommendations. [c]WWTPs serving parts of the same main city were considered all together for this calculation. [d]T: time-proportional (volume sampled/frequency of sampling); F: Flow-proportional

**Table S2.** Alcohol consumption rates estimated by means of WBE approach in different cities worldwide.

| City (Country) | Alcohol consumption (mL/day/inhabitant) | | Year | Reference |
|---|---|---|---|---|
| | Average | Range | | |
| Ho Chi Minh (Vietnam) | 3.1-3.9 | | 2015 | (Nguyen et al., 2018) |
| Lesvos (Greece) | 3.4/5.4 | 1.7-7.2/2.2-11.2 | 2015 | (Gatidou et al., 2016) |
| Valencia-PII (Spain) | 3.3[a] | 1.1-6.4[a] | 2014 | (Andrés-Costa et al., 2016) |
| Milan (Italy) | 5.1 | 3.2-10.5 | 2012-2014 | (Rodríguez-Álvarez et al., 2015) |
| | 6.4 | 5.1-8.1 | 2014 | (Ryu et al., 2016) |
| | 6.6 | | 2015 | (Baz-Lomba et al., 2016) |
| Valencia-QB (Spain) | 5.9[a] | 3.3-12.8[a] | 2014 | (Andrés-Costa et al., 2016) |
| Valencia-PII[b] (Spain) | 6.1[a] | 4.3-9.1[a] | 2014 | (Andrés-Costa et al., 2016) |
| Valencia-PI (Spain) | 6.2[a] | 1.1-18.31[a] | 2014 | (Andrés-Costa et al., 2016) |
| Lugano (Switzerland) | 6.5 | 4.5-8.4 | 2014 | (Ryu et al., 2016) |
| Toowoomba (Australia) | 9.7 | 6.9-14.5 | 2014 | (Ryu et al., 2016) |
| Utrecht (The Netherlands) | 10.8 | | 2015 | (Baz-Lomba et al., 2016) |
| | 12.9 | 7.7-20.7 | 2014 | (Ryu et al., 2016) |
| Santiago de Compostela (Spain) | 13.6 | 3.8-22.6 | 2012-2014 | (Rodríguez-Álvarez et al., 2015) |
| | 16.3 | 9.3-23.5 | 2012 | (Rodríguez-Álvarez et al., 2014) |
| Valencia-PII[b] | 14.4[a] | 4.9-23.8[a] | 2014 | (Andrés-Costa et al., 2016) |
| Almada (Portugal) | 14.6 | 8.4-24.1 | 2014 | (Ryu et al., 2016) |
| Canberra (Australia) | 14.6 | 9.3-22.3 | 2014 | (Ryu et al., 2016) |
| Zurich (Switzerland) | 14.7 | | 2015 | (Baz-Lomba et al., 2016) |
| Bristol (The United Kingdom) | 16.2 | | 2015 | (Baz-Lomba et al., 2016) |
| Berlin (Germany) | 16.9 | 13.8-22.3 | 2014 | (Ryu et al., 2016) |
| Oslo (Norway) | 16.1 | | 2009 | (Reid et al., 2011) |
| | 18.9 | | 2015 | (Baz-Lomba et al., 2016) |
| | 19.2 | 8.8-52.9 | 2014 | (Ryu et al., 2016) |
| Barcelona (Spain) | 18[a] | 7-31[a] | 2011-2015 | (Mastroianni et al., 2017) |
| Dülmen (Germany) | 20.3 | 5.5-40 | 2014 | (Ryu et al., 2016) |
| London (United Kingdom) | 21.5 | 10.9-36 | 2014 | (Ryu et al., 2016) |
| Brussels (Belgium) | 21.6 | | 2015 | (Baz-Lomba et al., 2016) |
| Eindhoven (The Netherlands) | 21.7 | 13.7-30.4 | 2014 | (Ryu et al., 2016) |
| Amsterdam (The Netherlands) | 22 | 14.3-30.5 | 2014 | (Ryu et al., 2016) |
| Castellón (Spain) | 23.4 | 11.6-61.6 | 2014 | (Ryu et al., 2016) |
| Dortmund (Germany) | 23.6 | 18.1-34 | 2014 | (Ryu et al., 2016) |

| | | | | |
|---|---|---|---|---|
| Munich (Germany) | 29.5 | 0.5-47.4 | 2014 | (Ryu et al., 2016) |
| Dresden (Germany) | 29.4 | 15.1-91.7 | 2014 | (Ryu et al., 2016) |
| Montreal (Canada) | 29.2 | 21.8-38.8 | 2014 | (Ryu et al., 2016) |
| Copenhagen (Denmark) | 29.7 | | 2015 | (Baz-Lomba et al., 2016) |
| | 40.2 | 24.6-74 | 2014 | (Ryu et al., 2016) |
| Granby (Canada) | 44.3 | 27.3-59.3 | 2014 | (Ryu et al., 2016) |
| Valencia-QB[b] | 40.9[a] | 27.0-56.1[a] | 2014 | (Andrés-Costa et al., 2016) |

[a]Alcohol consumption expressed in mL/day/inhabitant (aged 15+)
[b]Alcohol consumption rate during "Fallas festivity"

**Table S3.** Comparison of alcohol consumption between pairs of investigated populations (U Mann Whitney test p-values)[a].

| | Barcelona | Bilbao | Castellón | Guadalajara | Lleida | Madrid-La China | Madrid-Viveros | Móstoles | Palma de Mallorca | Reus | Santiago de Compostela | Tarragona | Toledo | Valencia-PI | Valencia-PII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bilbao | 0.114 | | | | | | | | | | | | | | |
| Castellón | 0.095 | 0.020* | | | | | | | | | | | | | |
| Guadalajara | 0.389 | 0.045* | 0.209 | | | | | | | | | | | | |
| Lleida | 0.114 | 0.012* | 0.789 | 0.287 | | | | | | | | | | | |
| Madrid-La China | 0.148 | 0.012* | 0.855 | 0.389 | 0.729 | | | | | | | | | | |
| Madrid-Viveros | 1.000 | 0.075 | 0.237 | 0.601 | 0.114 | 0.171 | | | | | | | | | |
| Móstoles | 0.855 | 0.389 | 0.045* | 0.095 | 0.075 | 0.075 | 0.534 | | | | | | | | |
| Palma de Mallorca | 0.925 | 0.060 | 0.075 | 0.237 | 0.070 | 0.070 | 0.855 | 0.789 | | | | | | | |
| Reus | 0.729 | 0.114 | 0.662 | 0.662 | 0.237 | 0.729 | 0.789 | 0.287 | 0.662 | | | | | | |
| Santiago de Compostela | 0.171 | 0.012* | 0.925 | 0.348 | 1.000 | 0.855 | 0.148 | 0.075 | 0.060 | 0.601 | | | | | |
| Tarragona | 0.389 | 0.662 | 0.114 | 0.209 | 0.070 | 0.095 | 0.287 | 0.534 | 0.389 | 0.171 | 0.075 | | | | |
| Toledo | 0.070 | 0.012* | 0.237 | 0.171 | 0.237 | 0.534 | 0.070 | 0.075 | 0.045* | 0.114 | 0.389 | 0.060 | | | |
| Valencia-PI | 0.459 | 0.045* | 0.237 | 0.662 | 0.237 | 0.389 | 0.729 | 0.389 | 0.348 | 0.925 | 0.287 | 0.209 | 0.171 | | |
| Valencia-PII | 0.925 | 0.012* | 0.171 | 0.729 | 0.148 | 0.171 | 0.601 | 0.237 | 0.601 | 0.789 | 0.114 | 0.237 | 0.075 | 1.000 | |
| Valencia-QB | 0.171 | 0.012* | 0.789 | 0.459 | 0.601 | 0.855 | 0.209 | 0.075 | 0.095 | 0.789 | 0.662 | 0.095 | 0.209 | 0.459 | 0.348 |

[a]Firstly, a non-parametric test (Kruskal Wallis test) was applied in order to compare alcohol consumption among all investigated populations since the number of data per city was $n < 10$. Since $p < 0.05$, (Kruskal Wallis p-value = 0.0003887), the null hypothesis ($H_0$: alcohol consumption among all investigated populations is equal) was rejected and a U Mann Whitney test was applied to compare alcohol consumption between pairs of populations. False Discovery Rate (FDR) correction for multiple testing was applied to reduce the number of "false positive".

*$p < 0.05$, null hypothesis in U Mann Whitney test ($H_0$: alcohol consumption between pairs of populations is equal) is rejected.

**Table S4.** Comparison of alcohol consumption between pairs of regions (U Mann Whitney test p-values)[a].

| | Castilla-La Mancha | Catalonia | Community of Madrid | Valencian Community | Galicia | Balearic Islands |
|---|---|---|---|---|---|---|
| Catalonia | 0.088 | | | | | |
| Community of Madrid | 0.088 | 1.000 | | | | |
| Valencian Community | 0.286 | 0.335 | 0.200 | | | |
| Galicia | 1.000 | 0.169 | 0.096 | 0.221 | | |
| Balearic Islands | 0.029* | 0.558 | 0.406 | 0.073 | 0.025* | |
| Basque Country | 0.001* | 0.073 | 0.020* | <0.001* | 0.004* | 0.025* |

[a]Firstly, a Kruskal Wallis test was applied in order to compare alcohol consumption among all investigated regions since for 3 regions (Galicia, Balearic Islands and Basque Country), $n < 10$. As p-value $< 0.05$ (Kruskal Wallis p-value = 0.000588), the null hypothesis ($H_0$: alcohol consumption among all regions is equal) was rejected and a U Mann Whitney test was applied to compare alcohol consumption between pairs of regions. False Discovery Rate (FDR) correction for multiple testing was applied to reduce the number of "false positive".

*$p < 0.05$ and null hypothesis in U Mann Whitney ($H_0$: alcohol consumption between pairs of regions is equal) is rejected.

**Table S5.** Average alcohol consumption estimated in Spain through WBE.

| | Alcohol consumption in the investigated populations | Alcohol consumption in Spain | | | | |
|---|---|---|---|---|---|---|
| | Kg/day | Kg/day | L/day | L/year/ inhabitants | L/year/ inhabitants (aged 15+) | L/year/ inhabitants (aged 18+) |
| Tuesday | 48187 | 376424 | 477090 | 3.7 | 4.4 | 4.6 |
| Wednesday | 50115 | 391487 | 496181 | 3.9 | 4.6 | 4.8 |
| Thursday | 55403 | 432792 | 548532 | 4.3 | 5.1 | 5.3 |
| Friday | 57734 | 451005 | 571616 | 4.5 | 5.3 | 5.5 |
| Saturday | 84030 | 656420 | 831965 | 6.5 | 7.7 | 8.0 |
| Sunday | 77172 | 602852 | 764071 | 6.0 | 7.1 | 7.3 |
| Monday | 62306 | 486721 | 616884 | 4.8 | 5.7 | 5.9 |
| *Average* | *62135* | *485386* | *615191* | *4.8* | *5.7* | *5.9* |
| *SD* | *13597* | *106216* | *134621* | *1.1* | *1.2* | *1.3* |

**Table S6.** Average alcohol consumption (mL/day/inhabitant (aged 15+)) in the investigated regions in this study and Spain reported by the National Health Survey (INE).

| | Week (Mon-Sun) | | Weekdays (Mon-Thurs) | | Weekend (Frid-Sun) | |
|---|---|---|---|---|---|---|
| | Average | sd | Average | sd | Average | sd |
| Balearic Island | 18 | 14 | 15 | 14 | 22 | 17 |
| Basque Country | 19 | 14 | 11 | 15 | 30 | 19 |
| Castilla-La Mancha | 13 | 13 | 7.5 | 13 | 20 | 17 |
| Catalonia | 16 | 13 | 10 | 13 | 23 | 17 |
| Community of Madrid | 14 | 16 | 8.0 | 16 | 21 | 18 |
| Galicia | 20 | 12 | 16 | 13 | 25 | 13 |
| Valencian Community | 14 | 11 | 8.5 | 12 | 22 | 15 |
| *Spain* | *13* | *12* | *8.4* | *12* | *19* | *16* |

Source: National Health Survey (INE, 2017).
https://www.ine.es/jaxi/Tabla.htm?path=/t15/p419/a2017/p03/l0/&file=03011.px&L=0


**Figure S1.** Map of Spain with the location of the sampled WWTPs (regions are indicated in different colors).

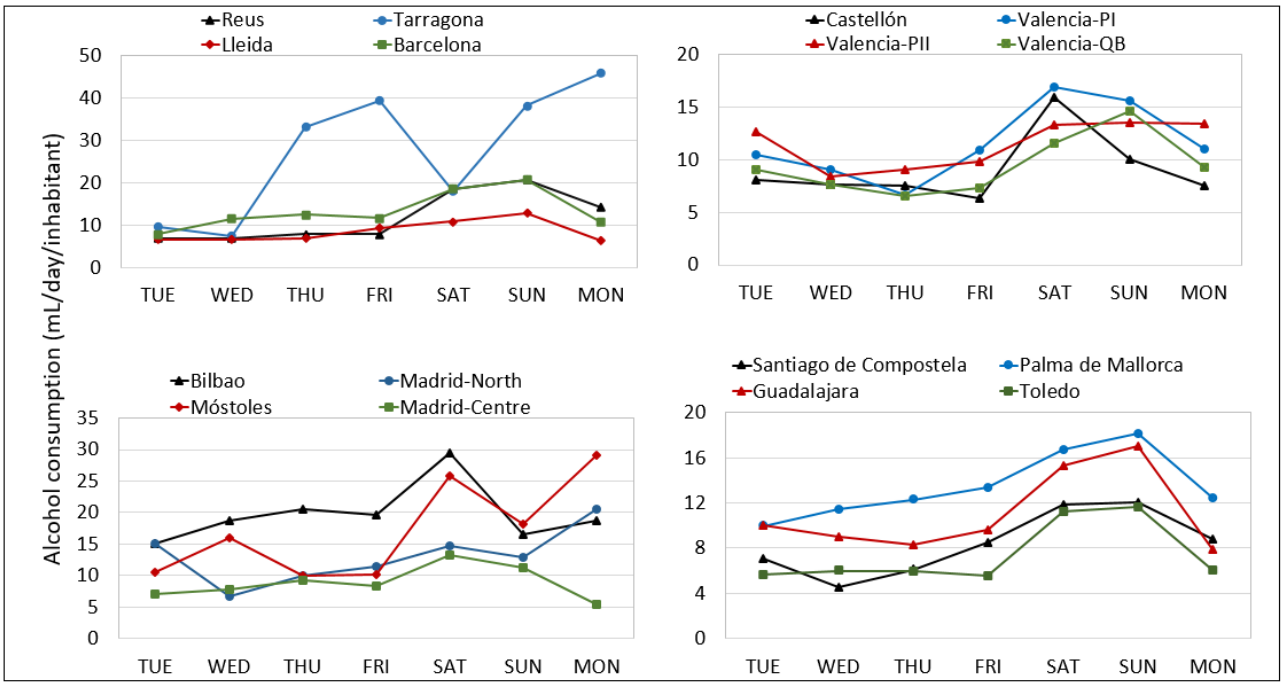


**Figure S2.** Weekly trends of alcohol consumption in the investigated populations.

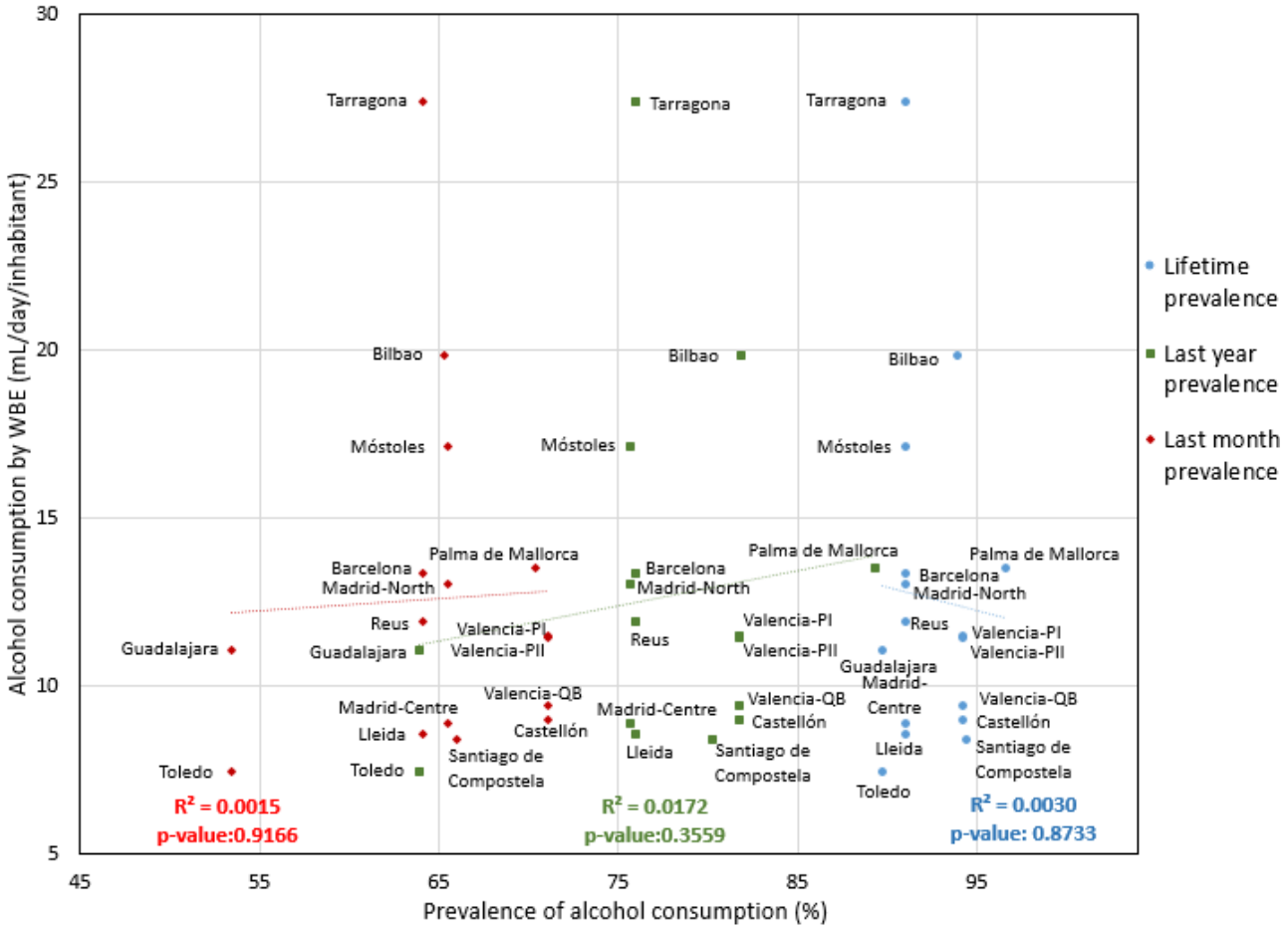


**Figure S3.** Correlation between average alcohol consumption estimated in each city by WBE (mL/day/inhabitant) and prevalence data ("Lifetime prevalence", "Last year prevalence" and "Last month prevalence") reported by its region in the annual Report of the Spanish Observatory on Drugs and Drugs Addiction 2019. (Data from all investigated populations are shown; Spearman correlation p-values < 0.05 were considered statistically significant).

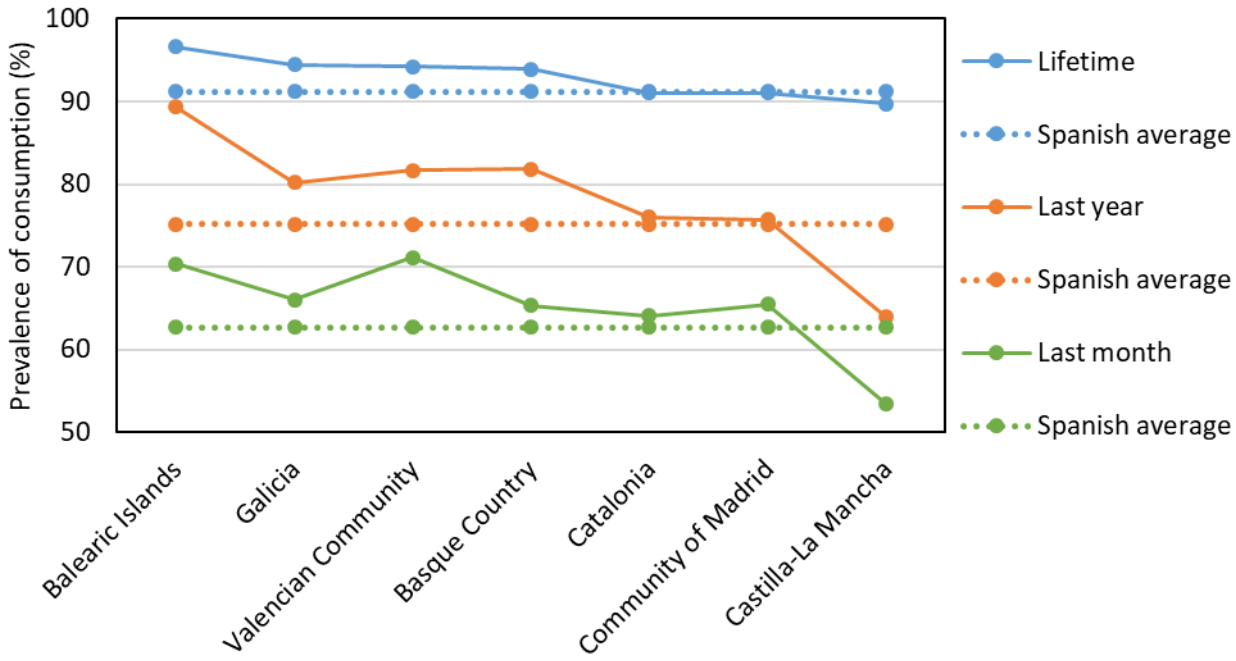


**Figure S4.** Prevalence data of alcohol consumption in the investigated regions and Spain reported in the Annual Report of the Spanish Observatory on Drugs and Drugs Addiction 2019.

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