

## Supplementary material

Table S1. Time range of data extraction and number of dogs retrieved from each data source.

| <b>Data source</b> | <b>Time range</b> | <b>Dogs (<i>n</i>)</b> |
|--------------------|-------------------|------------------------|
| IZSAM              | 2004–2013         | 216                    |
| IZSLER             | 2020              | 71                     |
| UNIBO              | 2011–2020         | 2028                   |
| UNIME              | 2012–2020         | 182                    |
| UNINA              | 2015–2020         | 199                    |
| UNIPD              | 2011–2020         | 79                     |
| UNIPG              | 2017–2020         | 150                    |
| UNIFI              | 2008–2020         | 1176                   |
| UNIPR              | 2015–2020         | 544                    |
| UNITE              | 2015–2020         | 226                    |
| UNITO              | 2009–2020         | 86                     |
| <b>Total</b>       |                   | <b>4957</b>            |

IZSAM – Istituto Zooprofilattico Sperimentale dell'Abruzzo e del Molise "Giuseppe Caporale"; IZSLER – Istituto Zooprofilattico sperimentale della Lombardia e dell'Emilia-Romagna "Bruno Ubertini"; UNIBO – University of Bologna; UNIME – University of Messina; UNINA – University of Naples; UNIPD – University of Padua; UNIPR – University of Parma; UNIPG – University of Perugia; UNIFI – University of Pisa; UNITE – University of Teramo; UNITO – University of Turin.

Table S2. Cause of death by pathophysiologic process (PP) and organ system (OS) in the overall dog population.

| PP →             |                   |                     |                   |                   |                     |                  |                   |              |                  |                 |                     |              |
|------------------|-------------------|---------------------|-------------------|-------------------|---------------------|------------------|-------------------|--------------|------------------|-----------------|---------------------|--------------|
| OS ↓             | <b>Congenital</b> | <b>Degenerative</b> | <b>Idiopathic</b> | <b>Infectious</b> | <b>Inflammatory</b> | <b>Metabolic</b> | <b>Neoplastic</b> | <b>Toxic</b> | <b>Traumatic</b> | <b>Vascular</b> | <b>Undetermined</b> | <b>Total</b> |
| Cardiovascular   | 19                | 361                 | 0                 | 18                | 31                  | 1                | 66                | 36           | 1                | 10              | 21                  | 564          |
| Dermatological   | 1                 | 0                   | 0                 | 11                | 0                   | 0                | 53                | 0            | 0                | 0               | 1                   | 66           |
| Endocrine        | 0                 | 0                   | 0                 | 0                 | 9                   | 74               | 83                | 0            | 0                | 0               | 1                   | 167          |
| Gastrointestinal | 1                 | 16                  | 0                 | 129               | 152                 | 13               | 97                | 4            | 50               | 134             | 29                  | 625          |
| Hematopoietic    | 4                 | 2                   | 0                 | 8                 | 56                  | 0                | 435               | 4            | 1                | 5               | 24                  | 539          |
| Hepatic          | 1                 | 38                  | 0                 | 13                | 15                  | 0                | 123               | 3            | 1                | 3               | 28                  | 225          |
| Musculoskeletal  | 8                 | 64                  | 0                 | 3                 | 4                   | 0                | 96                | 1            | 123              | 0               | 9                   | 308          |
| Neurological     | 6                 | 25                  | 19                | 27                | 36                  | 2                | 137               | 10           | 29               | 14              | 200                 | 505          |
| Renal/urinary    | 11                | 269                 | 0                 | 139               | 192                 | 1                | 50                | 3            | 7                | 1               | 15                  | 688          |
| Reproductive     | 0                 | 0                   | 0                 | 42                | 3                   | 0                | 112               | 0            | 0                | 1               | 0                   | 158          |
| Respiratory      | 6                 | 28                  | 1                 | 19                | 107                 | 0                | 89                | 5            | 19               | 37              | 37                  | 348          |
| Systemic         | 0                 | 0                   | 0                 | 111               | 66                  | 1                | 0                 | 6            | 184              | 7               | 27                  | 402          |
| Undetermined     | 0                 | 1                   | 0                 | 2                 | 2                   | 0                | 152               | 1            | 17               | 6               | 181                 | 362          |
| <b>Total</b>     | <b>57</b>         | <b>804</b>          | <b>20</b>         | <b>522</b>        | <b>673</b>          | <b>92</b>        | <b>1493</b>       | <b>73</b>    | <b>432</b>       | <b>218</b>      | <b>573</b>          | <b>4957</b>  |

Table S3. Percentage relative frequency (%) of deaths within pathophysiologic process (PP) categories for breeds with  $\geq 20$  representatives ( $n = 39$ ). Breeds are listed in alphabetical order. The main PP cause of death for each breed is highlighted by a box. Undetermined causes of death are shown but not considered when ranking the leading cause of death.

| Breed                             | C    | D    | ID  | IFC  | IFL  | M   | N    | TX  | TR   | V    | U    | Dogs<br>( <i>n</i> ) |
|-----------------------------------|------|------|-----|------|------|-----|------|-----|------|------|------|----------------------|
| American bulldog                  | 4.0  | 4.0  | 0.0 | 20.0 | 4.0  | 0.0 | 36.0 | 0.0 | 12.0 | 12.0 | 8.0  | 25                   |
| American pit bull terrier         | 4.8  | 4.8  | 0.0 | 23.8 | 14.3 | 4.8 | 19.0 | 4.8 | 14.3 | 4.8  | 4.8  | 21                   |
| American Staffordshire terrier    | 3.0  | 12.1 | 0.0 | 15.2 | 18.2 | 3.0 | 24.2 | 0.0 | 6.1  | 0.0  | 18.2 | 33                   |
| Beagle                            | 0.0  | 15.6 | 0.0 | 10.4 | 22.1 | 0.0 | 32.5 | 0.0 | 6.5  | 5.2  | 7.8  | 77                   |
| Bernese mountain dog              | 0.0  | 11.6 | 0.0 | 14.0 | 7.0  | 0.0 | 39.5 | 0.0 | 7.0  | 11.6 | 9.3  | 43                   |
| Border collie                     | 2.1  | 8.3  | 2.1 | 8.3  | 22.9 | 0.0 | 35.4 | 2.1 | 6.2  | 2.1  | 10.4 | 48                   |
| Boxer                             | 2.2  | 9.5  | 1.5 | 8.0  | 10.2 | 0.0 | 46.0 | 1.5 | 3.6  | 5.8  | 11.7 | 137                  |
| Brittany spaniel                  | 0.0  | 22.0 | 2.4 | 17.1 | 19.5 | 2.4 | 17.1 | 2.4 | 2.4  | 0.0  | 14.6 | 41                   |
| Cavalier King Charles spaniel     | 0.0  | 51.6 | 0.0 | 6.5  | 17.7 | 1.6 | 11.3 | 0.0 | 3.2  | 1.6  | 6.5  | 62                   |
| Chihuahua                         | 10.0 | 33.3 | 0.0 | 8.3  | 8.3  | 0.0 | 1.7  | 0.0 | 10.0 | 6.7  | 21.7 | 60                   |
| Dachshund                         | 1.1  | 25.0 | 0.0 | 12.0 | 16.3 | 4.3 | 23.9 | 3.3 | 7.6  | 4.3  | 2.2  | 92                   |
| Dobermann                         | 3.4  | 32.2 | 1.7 | 5.1  | 11.9 | 1.7 | 16.9 | 1.7 | 3.4  | 10.2 | 11.9 | 59                   |
| English bulldog                   | 9.1  | 12.1 | 3.0 | 18.2 | 21.2 | 3.0 | 18.2 | 0.0 | 0.0  | 6.1  | 9.1  | 33                   |
| English cocker spaniel            | 0.0  | 13.1 | 0.0 | 1.6  | 16.4 | 0.0 | 46.0 | 1.6 | 8.2  | 3.3  | 9.8  | 61                   |
| English setter                    | 1.0  | 9.0  | 1.0 | 14.0 | 14.0 | 2.0 | 34.0 | 4.0 | 4.0  | 4.0  | 13.0 | 100                  |
| English springer spaniel          | 0.0  | 17.6 | 0.0 | 20.6 | 14.7 | 2.9 | 23.5 | 2.9 | 5.9  | 5.9  | 5.9  | 34                   |
| French bulldog                    | 2.2  | 6.5  | 0.0 | 8.7  | 19.6 | 4.3 | 39.1 | 0.0 | 0.0  | 2.2  | 17.4 | 46                   |
| German shepherd                   | 0.7  | 10.5 | 0.0 | 8.7  | 10.1 | 1.0 | 38.0 | 2.4 | 7.0  | 10.8 | 10.8 | 287                  |
| German shorthaired pointing dog   | 0.0  | 3.7  | 0.0 | 29.6 | 11.1 | 3.7 | 18.5 | 0.0 | 18.5 | 7.4  | 7.4  | 27                   |
| Golden retriever                  | 1.8  | 16.5 | 0.9 | 8.3  | 12.8 | 0.0 | 38.5 | 0.0 | 4.6  | 0.9  | 15.6 | 109                  |
| Italian cane corso                | 0.0  | 11.1 | 0.0 | 14.8 | 3.7  | 1.9 | 40.7 | 0.0 | 5.6  | 5.6  | 16.7 | 54                   |
| Italian segugio                   | 0.0  | 9.8  | 2.4 | 29.3 | 7.3  | 2.4 | 17.1 | 4.9 | 14.6 | 0.0  | 12.2 | 41                   |
| Italian volpino                   | 0.0  | 25.0 | 0.0 | 5.0  | 35.0 | 0.0 | 20.0 | 5.0 | 10.0 | 0.0  | 0.0  | 20                   |
| Jack Russell terrier              | 3.0  | 18.2 | 0.0 | 9.1  | 21.2 | 0.0 | 21.2 | 3.0 | 12.1 | 0.0  | 12.1 | 66                   |
| Labrador retriever                | 0.5  | 12.1 | 0.0 | 9.8  | 15.0 | 1.4 | 38.8 | 2.8 | 4.7  | 3.3  | 11.7 | 214                  |
| Maltese                           | 4.1  | 31.5 | 0.0 | 13.7 | 11.0 | 1.4 | 19.2 | 1.4 | 5.5  | 4.1  | 8.2  | 73                   |
| Maremma and the Abruzzes sheepdog | 1.8  | 12.7 | 0.0 | 14.5 | 9.1  | 0.0 | 23.6 | 0.0 | 10.9 | 16.4 | 10.9 | 55                   |
| Mixed-breed                       | 0.6  | 15.7 | 0.3 | 9.5  | 12.2 | 2.4 | 30.7 | 1.3 | 11.6 | 3.6  | 12.1 | 2037                 |
| Pinscher (miniature)              | 2.4  | 28.0 | 0.0 | 7.3  | 18.3 | 0.0 | 15.9 | 3.7 | 12.2 | 0.0  | 12.2 | 82                   |
| Pointer                           | 0.0  | 18.2 | 0.0 | 9.1  | 18.2 | 0.0 | 22.7 | 4.5 | 13.6 | 4.5  | 9.1  | 22                   |
| Pomeranian                        | 5.0  | 20.0 | 5.0 | 10.0 | 20.0 | 0.0 | 5.0  | 0.0 | 15.0 | 15.0 | 5.0  | 20                   |
| Poodle (miniature)                | 0.0  | 12.8 | 0.0 | 6.4  | 12.8 | 4.3 | 42.6 | 0.0 | 6.4  | 2.1  | 12.8 | 47                   |
| Poodle (toy)                      | 2.2  | 35.6 | 0.0 | 15.6 | 11.1 | 6.7 | 13.3 | 0.0 | 6.7  | 0.0  | 8.9  | 45                   |
| Pug                               | 4.9  | 7.3  | 0.0 | 7.3  | 17.1 | 2.4 | 34.1 | 0.0 | 4.9  | 4.9  | 17.1 | 41                   |

|                             |     |      |     |      |      |      |      |     |      |     |      |    |
|-----------------------------|-----|------|-----|------|------|------|------|-----|------|-----|------|----|
| Romagna water dog           | 0.0 | 10.0 | 0.0 | 10.0 | 12.5 | 0.0  | 30.0 | 5.0 | 10.0 | 2.5 | 20.0 | 40 |
| Rottweiler                  | 2.7 | 9.5  | 0.0 | 10.8 | 6.8  | 0.0  | 52.7 | 1.4 | 5.4  | 1.4 | 9.5  | 74 |
| Shih Tzu                    | 2.3 | 20.5 | 0.0 | 6.8  | 13.6 | 0.0  | 31.8 | 0.0 | 4.5  | 6.8 | 13.6 | 44 |
| West Highland white terrier | 0.0 | 24.3 | 0.0 | 10.8 | 21.6 | 2.7  | 21.6 | 0.0 | 2.7  | 5.4 | 10.8 | 37 |
| Yorkshire terrier           | 1.5 | 23.9 | 0.0 | 6.0  | 16.4 | 10.4 | 20.9 | 1.5 | 4.5  | 1.5 | 13.4 | 67 |

C – Congenital; D – Degenerative; ID – Idiopathic; IFC – Infectious; IFL – Inflammatory; M – Metabolic; N – Neoplastic; TX – Toxic; TR – Traumatic; V – Vascular; U – Undetermined

Table S4. Percentage relative frequency (%) of deaths within organ system (OS) categories for breeds with  $\geq 20$  representatives ( $n = 39$ ). Breeds are listed in alphabetical order. The main OS cause of death for each breed is highlighted by a box. Undetermined causes of death are shown but not considered when ranking the leading cause of death.

| Breed                             | C    | D   | E   | GI   | HP   | HE   | MS   | N    | RU       | RP   | RS   | S    | U    | Dogs (n) |
|-----------------------------------|------|-----|-----|------|------|------|------|------|----------|------|------|------|------|----------|
| American bulldog                  | 16.0 | 0.0 | 4.0 | 8.0  | 8.0  | 4.0  | 12.0 | 12.0 | 12.0     | 8.0  | 4.0  | 4.0  | 8.0  | 25       |
| American pit bull terrier         | 9.5  | 0.0 | 9.5 | 33.3 | 4.8  | 0.0  | 4.8  | 19.0 | 4.8      | 0.0  | 0.0  | 9.5  | 4.8  | 21       |
| American Staffordshire terrier    | 9.1  | 3.0 | 3.0 | 9.1  | 6.1  | 3.0  | 12.1 | 12.1 | 21.2     | 6.1  | 3.0  | 6.1  | 6.1  | 33       |
| Beagle                            | 6.5  | 0.0 | 0.0 | 15.6 | 15.6 | 5.2  | 3.9  | 6.5  | 24.7     | 0.0  | 7.8  | 10.4 | 3.9  | 77       |
| Bernese mountain dog              | 2.3  | 0.0 | 0.0 | 16.3 | 23.3 | 2.3  | 4.7  | 7.0  | 16.3     | 2.3  | 9.3  | 9.3  | 7.0  | 43       |
| Border collie                     | 4.2  | 2.1 | 6.2 | 6.2  | 10.4 | 10.4 | 6.2  | 12.5 | 16.7     | 2.1  | 4.2  | 10.4 | 8.3  | 48       |
| Boxer                             | 8.8  | 0.7 | 4.4 | 13.9 | 13.9 | 2.2  | 5.8  | 19.7 | 13.1     | 2.9  | 2.9  | 7.3  | 4.4  | 137      |
| Brittany spaniel                  | 14.6 | 0.0 | 2.4 | 9.8  | 7.3  | 2.4  | 4.9  | 9.8  | 29.3     | 2.4  | 4.9  | 9.8  | 2.4  | 41       |
| Cavalier King Charles spaniel     | 53.2 | 0.0 | 4.8 | 9.7  | 1.6  | 1.6  | 1.6  | 4.8  | 3.2      | 3.2  | 4.8  | 8.1  | 3.2  | 62       |
| Chihuahua                         | 33.3 | 0.0 | 0.0 | 6.7  | 0.0  | 0.0  | 10.0 | 23.3 | 5.0      | 0.0  | 18.3 | 3.3  | 0.0  | 60       |
| Dachshund                         | 17.4 | 2.2 | 6.5 | 12.0 | 7.6  | 5.4  | 5.4  | 5.4  | 8.7      | 5.4  | 9.8  | 13.0 | 1.1  | 92       |
| Dobermann                         | 23.7 | 1.7 | 3.4 | 15.3 | 6.8  | 3.4  | 6.8  | 8.5  | 16.9     | 3.4  | 0.0  | 1.7  | 8.5  | 59       |
| English bulldog                   | 9.1  | 0.0 | 0.0 | 6.1  | 9.1  | 0.0  | 3.0  | 9.1  | 9.1      | 3.0  | 24.2 | 18.2 | 9.1  | 33       |
| English cocker spaniel            | 4.9  | 3.3 | 4.9 | 9.8  | 18.0 | 6.6  | 4.9  | 11.5 | 14.8     | 4.9  | 4.9  | 4.9  | 6.6  | 61       |
| English setter                    | 10.0 | 2.0 | 6.0 | 8.0  | 9.0  | 2.0  | 6.0  | 8.0  | 19.0     | 6.0  | 9.0  | 8.0  | 7.0  | 100      |
| English springer spaniel          | 11.8 | 0.0 | 2.9 | 11.8 | 11.8 | 5.9  | 5.9  | 2.9  | 20.6     | 2.9  | 8.8  | 11.8 | 2.9  | 34       |
| French bulldog                    | 8.7  | 0.0 | 8.7 | 2.2  | 15.2 | 2.2  | 4.3  | 15.2 | 10.9     | 4.3  | 15.2 | 8.7  | 4.3  | 46       |
| German shepherd                   | 9.8  | 1.4 | 1.7 | 19.9 | 19.5 | 3.8  | 3.1  | 8.0  | 11.1     | 3.8  | 3.1  | 6.3  | 8.4  | 287      |
| German shorthaired pointing dog   | 3.7  | 0.0 | 3.7 | 11.1 | 7.4  | 7.4  | 7.4  | 3.7  | 11.1     | 11.1 | 7.4  | 18.5 | 7.4  | 27       |
| Golden retriever                  | 5.5  | 2.8 | 0.9 | 15.6 | 20.2 | 5.5  | 2.8  | 11.0 | 14.7     | 2.8  | 4.6  | 5.5  | 8.3  | 109      |
| Italian cane corso                | 9.3  | 1.9 | 0.0 | 18.5 | 9.3  | 5.6  | 9.3  | 9.3  | 9.3      | 5.6  | 9.3  | 1.9  | 11.1 | 54       |
| Italian segugio                   | 9.8  | 0.0 | 4.9 | 22.0 | 4.9  | 2.4  | 2.4  | 4.9  | 1<br>4.6 | 7.3  | 4.9  | 17.1 | 4.9  | 41       |
| Italian volpino                   | 10.0 | 0.0 | 0.0 | 15.0 | 15.0 | 0.0  | 10.0 | 5.0  | 25.0     | 10.0 | 5.0  | 0.0  | 5.0  | 20       |
| Jack Russell terrier              | 16.7 | 0.0 | 0.0 | 12.1 | 7.6  | 7.6  | 6.1  | 4.5  | 18.2     | 3.0  | 6.1  | 7.6  | 10.6 | 66       |
| Labrador retriever                | 6.1  | 2.3 | 3.3 | 9.8  | 15.4 | 9.3  | 3.3  | 10.3 | 16.8     | 1.9  | 7.0  | 7.0  | 7.5  | 214      |
| Maltese                           | 19.2 | 0.0 | 6.8 | 12.3 | 8.2  | 11.0 | 5.5  | 11.0 | 12.3     | 1.4  | 4.1  | 4.1  | 4.1  | 73       |
| Maremma and the Abruzzes sheepdog | 7.3  | 3.6 | 0.0 | 16.4 | 7.3  | 12.7 | 5.5  | 12.7 | 3.6      | 3.6  | 10.9 | 12.7 | 3.6  | 55       |
| Mixed-breed                       | 10.4 | 1.2 | 3.6 | 11.6 | 9.7  | 4.5  | 7.5  | 10.8 | 13.3     | 3.1  | 7.1  | 8.3  | 8.9  | 2037     |
| Pinscher (miniature)              | 20.7 | 2.4 | 1.2 | 12.2 | 6.1  | 3.7  | 3.7  | 8.5  | 19.5     | 1.2  | 7.3  | 8.5  | 4.9  | 82       |
| Pointer                           | 13.6 | 0.0 | 0.0 | 18.2 | 0.0  | 0.0  | 9.1  | 4.5  | 18.2     | 0.0  | 0.0  | 18.2 | 18.2 | 22       |
| Pomeranian                        | 20.0 | 0.0 | 0.0 | 10.0 | 5.0  | 0.0  | 5.0  | 10.0 | 10.0     | 0.0  | 20.0 | 20.0 | 0.0  | 20       |

|                             |      |     |      |      |      |     |      |      |      |     |      |      |      |    |
|-----------------------------|------|-----|------|------|------|-----|------|------|------|-----|------|------|------|----|
| Poodle (miniature)          | 8.5  | 0.0 | 10.6 | 10.6 | 6.4  | 6.4 | 4.3  | 10.6 | 10.6 | 8.5 | 8.5  | 10.6 | 4.3  | 47 |
| Poodle (toy)                | 22.2 | 2.2 | 8.9  | 17.8 | 0.0  | 4.4 | 6.7  | 13.3 | 8.9  | 4.4 | 8.9  | 2.2  | 0.0  | 45 |
| Pug                         | 7.3  | 2.4 | 2.4  | 7.3  | 14.6 | 0.0 | 0.0  | 12.2 | 4.9  | 2.4 | 22.0 | 7.3  | 17.1 | 41 |
| Romagna water dog           | 10.0 | 2.5 | 0.0  | 7.5  | 7.5  | 7.5 | 10.0 | 22.5 | 7.5  | 2.5 | 2.5  | 5.0  | 15.0 | 40 |
| Rottweiler                  | 10.8 | 1.4 | 1.4  | 12.2 | 21.6 | 4.1 | 10.8 | 8.1  | 9.5  | 4.1 | 2.7  | 6.8  | 6.8  | 74 |
| Shih Tzu                    | 18.2 | 6.8 | 0.0  | 15.9 | 6.8  | 0.0 | 9.1  | 2.3  | 6.8  | 6.8 | 15.9 | 4.5  | 6.8  | 44 |
| West Highland white terrier | 0.0  | 2.7 | 2.7  | 10.8 | 13.5 | 0.0 | 2.7  | 5.4  | 21.6 | 0.0 | 27.0 | 8.1  | 5.4  | 37 |
| Yorkshire terrier           | 13.4 | 3.0 | 13.4 | 11.9 | 6.0  | 3.0 | 1.5  | 14.9 | 13.4 | 4.5 | 10.4 | 3.0  | 1.5  | 67 |

C – Cardiovascular; D – Dermatological; E – Endocrine; GI – Gastrointestinal; HP – Haematopoietic; HE – Hepatic; MS – Musculoskeletal; N – Neurological; RU – Renal/Urinary; RP – Reproductive; RS – Respiratory; S – Systemic; U – Undetermined

Fig. S1. Distribution of sex in the different age groups, showed in 2-year age bands. F – Female; M – Male.

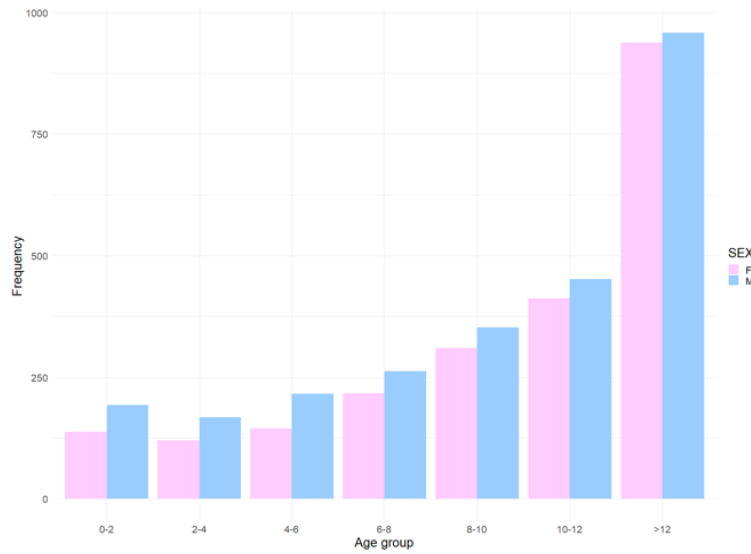


Fig. S2. Box plot showing the median age at death (years) and interquartile range of all the dogs included in the sample according to sex ( $n = 4921$ ). Female ( $n = 2293$ ); Male ( $n = 2628$ );  $P < 0.0001$ . Dots denote observations exceeding the interquartile range (IQR) more than 1.5 times.

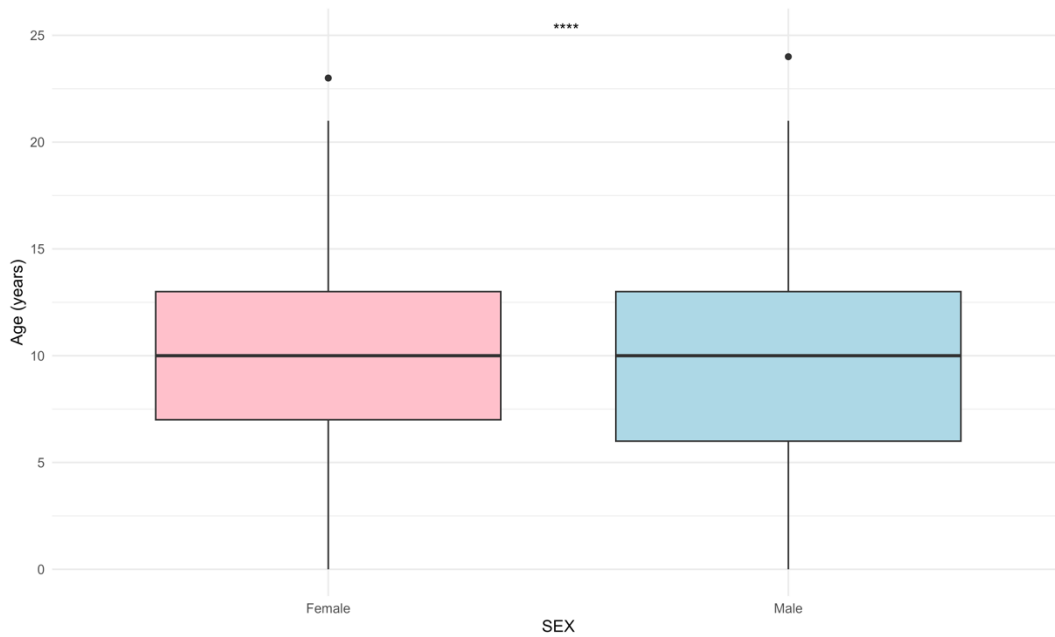


Fig. S3. Box plot showing the median age at death (years) and interquartile range in those breeds where the difference between males and females was statistically significant ( $P < 0.05$ ). A: Dogo argentino; B: Mixed-breed; C: Italian volpino. Dots denote observations exceeding the interquartile range (IQR) more than 1.5 times.

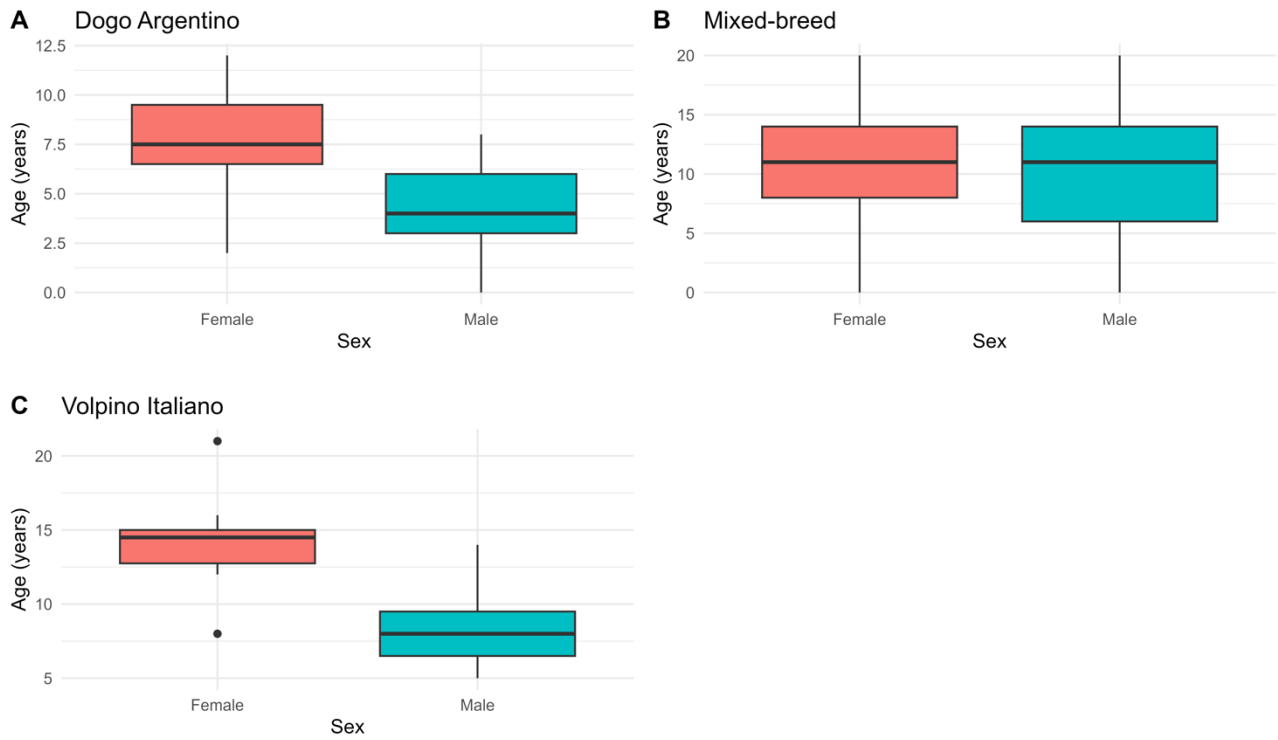




Fig. S4. Stacked bar graph showing the percentage relative frequency (%) of deaths within pathophysiologic process (PP) categories in purebred dogs of different size. Undetermined causes of death were excluded from the analysis.

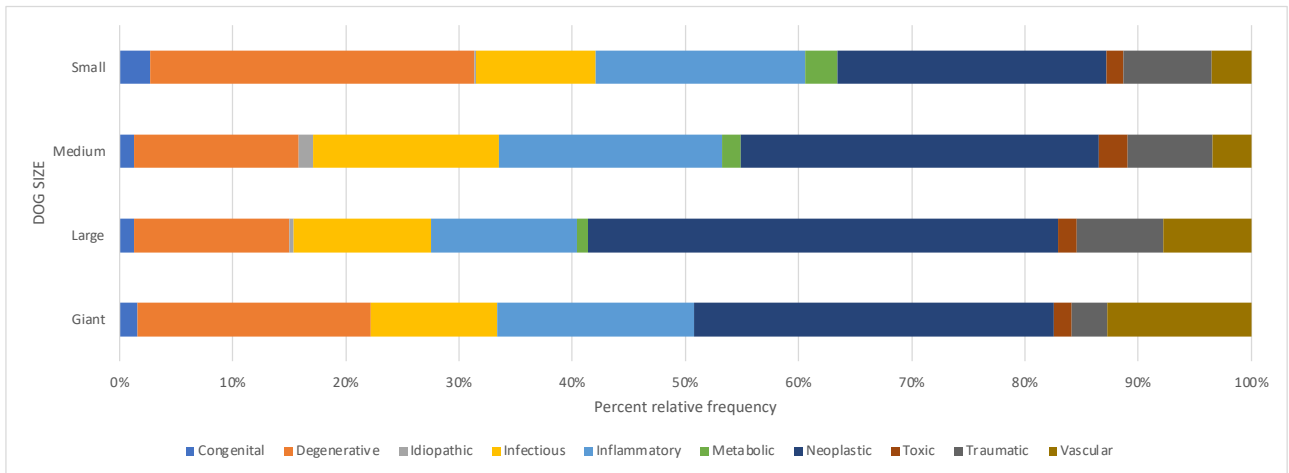


Fig. S5. Stacked bar graph showing the percentage relative frequency (%) of deaths within organ system (OS) categories in purebred dogs of different size. Undetermined causes of death were excluded from the analysis.

