

## **Dairy foods and health: an umbrella review of observational studies**

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Supplementary Table 1. Summary results from meta-analyses investigating continuous linear exposure to dairy (total and individual foods) consumption and health outcomes. NA, not available.

| Outcome                     | Number of Studies | Exposure (increment) | RR                | I <sup>2</sup> | Reference                    |
|-----------------------------|-------------------|----------------------|-------------------|----------------|------------------------------|
| <b>Butter</b>               |                   |                      |                   |                |                              |
| CVD (any)                   | 4                 | 14 g/d               | 1.00 (0.98, 1.02) | 0%             | Pimpin et al. 2016           |
| Stroke                      | 3                 | 14 g/d               | 1.01 (0.98, 1.03) | 0%             | Pimpin et al. 2016           |
| Type 2 diabetes             | 4                 | 14 g/d               | 0.96 (0.93, 0.99) | 46%            | Pimpin et al. 2016           |
| <b>Cheese</b>               |                   |                      |                   |                |                              |
| Advanced prostate cancer    | 5                 | 50 g/d               | 1.06 (0.76, 1.48) | 57%            | Aune et al. 2015             |
| All-cause mortality         | 5                 | 40 g/d               | 1.00 (1.00, 1.00) | NA             | O'Sullivan et al. 2013       |
| CHD                         | 8                 | 50 g/d               | 0.90 (0.84, 0.95) | 0%             | Chen et al. 2017             |
| Colorectal cancer           | 7                 | 50 g/d               | 0.96 (0.83, 1.12) | 28%            | Aune et al. 2012             |
| CVD                         | 7                 | 50 g/d               | 0.92 (0.83, 1.02) | 16%            | Chen et al. 2017             |
| CVD mortality               | 3                 | 40 g/d               | 1.01 (0.99, 1.02) | NA             | O'Sullivan et al. 2013       |
| Nonadvanced prostate cancer | 4                 | 50 g/d               | 1.16 (0.96, 1.40) | 40%            | Aune et al. 2015             |
| Parkinson's disease         | 3                 | 10 g/d               | 1.13 (0.91, 1.40) | NA             | Jiang et al. 2014            |
| Prostate cancer             | 11                | 50 g/d               | 1.10 (1.03, 1.18) | 0%             | Aune et al. 2015             |
| Stroke                      | 5                 | 50 g/d               | 0.94 (0.84, 1.04) | 63%            | Chen et al. 2017             |
| Type 2 diabetes             | 12                | 10 g/d               | 1.00 (0.99, 1.02) | 62%            | Gijsbers et al. 2016         |
| <b>Milk</b>                 |                   |                      |                   |                |                              |
| Advanced prostate cancer    | 4                 | 200 g/d              | 0.98 (0.89, 1.09) | 0%             | Aune et al. 2015             |
| All-cause mortality         | 11                | 200 ml/d             | 1.01 (0.96, 1.06) | 94%            | Mullie et al. 2016           |
| CHD                         | 9                 | 200 ml/d             | 1.01 (0.98, 1.05) | 16%            | Mullie et al. 2016           |
| Colorectal cancer           | 9                 | 200 g/d              | 0.90 (0.85, 0.94) | 0%             | Aune et al. 2012             |
| CVD mortality               | 5                 | 200 ml/d             | 1.00 (0.99, 1.00) | NA             | O'Sullivan et al. 2013       |
| Hip fracture in men         | 3                 | 1 glass/d            | 0.91 (0.81, 1.01) | NA             | Bischoff-Ferrari et al. 2011 |
| Hip fracture in woman       | 6                 | 1 glass/d            | 0.99 (0.96, 1.02) | NA             | Bischoff-Ferrari et al. 2011 |
| Kidney stones               | 3                 | 1 serv/d             | 0.94 (0.86, 1.04) | 55%            | Xu et al. 2015               |
| Nonadvanced prostate cancer | 4                 | 200 g/d              | 1.06 (1.00, 1.13) | 0%             | Aune et al. 2015             |
| Parkinson's disease         | 4                 | 200 g/d              | 1.17 (1.06, 1.30) | NA             | Jiang et al. 2014            |

|                              |          |              |                   |       |                            |
|------------------------------|----------|--------------|-------------------|-------|----------------------------|
| Stroke hemorrhagic           | 4        | 125 g/d      | 0.76 (0.70, 0.82) | NA    | de Goede et al. 2016       |
| Stroke ischaemic             | 5        | 115 g/d      | 0.90 (0.85, 0.96) | NA    | de Goede et al. 2016       |
| Stroke mortality             | 7        | 200 g/d      | 0.88 (0.81, 0.96) | 65%   | de Goede et al. 2016       |
| Type 2 diabetes              | 11       | 200 g/d      | 0.97 (0.93, 1.02) | 57%   | Gijsbers et al. 2016       |
| Advanced prostate cancer*    | 4        | 200 g/d      | 0.99 (0.93, 1.05) | 0%    | Aune et al. 2015           |
| Nonadvanced prostate cancer* | 4        | 200 g/d      | 1.09 (1.01, 1.17) | 77,1% | Aune et al. 2015           |
| Prostate cancer*             | 5        | 200 g/d      | 1.06 (1.01, 1.11) | 67%   | Aune et al. 2015           |
| Type 2 diabetes*             | 7        | 200 g/d      | 1.01 (0.97, 1.05) | 72%   | Gijsbers et al. 2016       |
| Advanced prostate cancer§    | 4        | 200 g/d      | 0.96 (0.87, 1.06) | 0%    | Aune et al. 2015           |
| Nonadvanced prostate cancer§ | 4        | 200 g/d      | 0.94 (0.88, 1.00) | 33,7% | Aune et al. 2015           |
| Prostate cancer§             | 6        | 200 g/d      | 0.98 (0.95, 1.01) | 0%    | Aune et al. 2015           |
| Type 2 diabetes§             | 9        | 200 g/d      | 0.99 (0.88, 1.11) | 84%   | Gijsbers et al. 2016       |
| <b>Total dairy</b>           |          |              |                   |       |                            |
| Advanced prostate cancer     | 10       | 400 g/d      | 0.97 (0.91, 1.05) | 0%    | Aune et al. 2015           |
| Breast cancer                | NA       | 250g/d       | 0.85 (0.76, 0.94) | NA    | Zang et al. 2015           |
| CHD                          | 9        | 1.5-3 serv/d | 0.93 (0.85, 1.00) | 52%   | Alexander et al. 2016      |
| Colorectal cancer            | 10       | 400 g/d      | 0.83 (0.78, 0.88) | 25%   | Aune et al. 2012           |
| Fatal prostate cancer        | 5        | 400 g/d      | 1.11 (0.92, 1.33) | 20%   | Aune et al. 2015           |
| Hypertension                 | 9        | 200 g/d      | 0.97 (0.95, 0.99) | 28%   | Soedamah-Muthu et al. 2012 |
| Metabolic syndrome           | 4        | 1 serv/day   | 0.88 (0.82, 0.95) | 55,6% | Kim et al. 2016            |
| Nonadvanced prostate cancer  | 8        | 400g/day     | 1.09 (1.00, 1.18) | 53%   | Aune et al. 2015           |
| Stroke hemorrhagic           | 3        | 200 g/day    | 1.02 (0.98, 1.06) | 0%    | de Goede et al. 2016       |
| Stroke ischaemic             | 3        | 200 g/day    | 1.00 (0.96, 1.04) | 68%   | de Goede et al. 2016       |
| Stroke mortality             | 4        | 200 g/day    | 0.97 (0.85, 1.11) | 65%   | de Goede et al. 2016       |
| Type 2 diabetes              | 16       | 200 g/day    | 0.97 (0.95, 1.00) | 66%   | Gijsbers et al. 2016       |
| <b>Yogurt</b>                |          |              |                   |       |                            |
| Prostate cancer              | 6        | 100g/day     | 1.08 (0.93, 1.24) | 82%   | Aune et al. 2015           |
| Type 2 diabetes              | 11/12sub | 50g/d        | 0.94 (0.90, 0.97) | 73%   | Gijsbers et al. 2016       |

\*refers to low-fat milk

§ refers to whole milk

Supplementary Table 2. Significance and direction of results from selected meta-analyses on dairy (total and individual foods) consumption and health outcomes. “S” denotes significant results; NS denotes non-significant results; symbols “+” and “-” denote direction of the association. NA, not available.

[illegible]

|                         |    |    |    |    |    |    |    |    |    |           |                        |
|-------------------------|----|----|----|----|----|----|----|----|----|-----------|------------------------|
| Bladder Cancer          | NS | NA | NA | NA | NA | NA | NA | S- | NS | NS        | Li et al. 2011         |
| Breast cancer           | NS | NS | NS | NA | NS | NA | NA | NS | NS | NS        | Wu et al. 2016         |
| Elevated blood pressure | S- | NA | NA | NA | NA | NA | NA | NA | NA | NA        | Ralston et al. 2012    |
| Stroke mortality        | NS | NA | NA | NA | NA | NA | NA | NA | NA | NA        | Hu et al. 2014         |
| Stroke ischaemic        | NS | NA | NA | NA | NA | NA | NA | NA | NA | NA        | Alexander et al. 2016  |
| Stroke hemorrhagic      | NS | NA | NA | NA | NA | NA | NA | NA | NA | NA        | Alexander et al. 2016  |
| CVD                     | NS | NA | NA | NA | NA | NA | NA | NA | NA | NA        | Alexander et al. 2016  |
| Lung cancer             | NS | NA | NA | NA | S+ | NA | NA | NA | NA | NA        | Yu et al. 2016         |
| CVD mortality           | NS | NA | NA | NA | NA | NA | NA | NS | NS | S-        | O'Sullivan et al. 2013 |
| All-cause mortality     | NS | NA | NA | NA | NA | NA | NA | NA | NA | NA        | O'Sullivan et al. 2013 |
| CHD                     | NS | NA | NA | NA | NA | NS | NS | NA | NS | NA        | Alexander et al. 2016  |
| Gastic cancer           | NS | NA | NA | NA | NA | NS | NS | NS | NS | S-        | Sun et al. 2014        |
| Prostate cancer         | S+ | NS | S+ | NA | NS | NA | NA | S+ | NS | NS        | Aune et al. 2015       |
| Parkinson's disease     | S+ | NA | NA | NA | NA | NA | NA | NA | NA | NA        | Jiang et al. 2014      |
| <b>Total dairy</b>      |    |    |    |    |    |    |    |    |    |           |                        |
| Stroke mortality        | S- | NA | NA | NA | NA | NA | NA | NA | NA | NA        | Hu et al. 2014         |
| Colorectal cancer       | S- | S- | S- | NA | S- | S- | S- | S- | S- | 0 studies | Aune et al. 2012       |
| Metabolic syndrome      | S- | S- | NS | NA | NA | NA | NA | NS | NS | NS        | Kim et al. 2016        |
| CVD mortality           | NS | NA | NA | NA | NA | NA | NA | NA | NA | NA        | O'Sullivan et al. 2013 |
| Elevated blood pressure | S- | NA | NA | NA | NA | NA | NA | NA | NA | NA        | Ralston et al. 2012    |
| Stroke                  | S- | NA | NA | NA | NA | NS | S- | S- | NS | S-        | Hu et al. 2014         |
| CVD                     | S- | NA | NA | NA | NA | NA | NA | NA | NA | NA        | Qin et al. 2015        |
| Type 2 diabetes         | S- | S- | S- | NA | NS | NS | S- | S- | NS | NS        | Aune et al. 2013       |
| Breast cancer           | S- | NA | NA | NA | NA | NA | NA | S- | NS | 0 studies | Zang et al. 2015       |
| Stroke ischaemic        | NS | NA | NA | NA | NA | NA | NA | NA | NA | NA        | Hu et al. 2014         |
| CHD                     | NS | NA | NA | NA | NA | NA | NA | NA | NA | NA        | Qin et al. 2015        |
| Lung cancer             | NS | NA | NA | NA | NS | NA | NA | NA | NA | NA        | Yu et al. 2016         |
| Stroke hemorrhagic      | NS | NA | NA | NA | NA | NA | NA | NA | NA | NA        | Hu et al. 2014         |
| Cancer mortality        | NS | NA | NA | NA | NA | NS | NS | NS | NS | NS        | Lu et al. 2016         |



Supplementary Table 3. Results of meta-analyses (highest vs. lowest category of exposure) on dairy (total and individual foods) consumption and health outcomes with limited number of prospective cohort studies (<3) or case-control studies (either alone or mixed with prospective cohort studies).

| Outcome                                                  | Number of Studies | Type of Study Included     | RR                | I2    | Reference           |
|----------------------------------------------------------|-------------------|----------------------------|-------------------|-------|---------------------|
| <b>Total dairy</b>                                       |                   |                            |                   |       |                     |
| Bladder Cancer                                           | 16                | Prospective + case-control | 0.84 (0.72, 0.97) | 70,1% | Mao et al. 2011     |
| Diffuse large B-cell lymphoma                            | 3                 | Prospective + case-control | 1.73 (1.22, 2.45) | 0%    | Wang et al. 2016    |
| Endometrial cancer*                                      | 6                 | Case-control               | 0.97 (0.93, 1.01) | 0%    | Bandera et al. 2007 |
| Esophageal squamous cell                                 | 5                 | Case-control               | 1.03 (0.60, 1.77) | 81,8% | Li et al. 2016      |
| Follicular lymphoma                                      | 3                 | Prospective + case-control | 1.23 (0.88, 1.72) | 0%    | Wang et al. 2016    |
| Ovarian Cancer                                           | 2                 | Prospective                | 1.66 (1.19, 2.31) | 0%    | Larsson et al. 2006 |
| <b>Milk</b>                                              |                   |                            |                   |       |                     |
| Chronic lymphocytic leukaemia/Small lymphocytic lymphoma | 3                 | Prospective + case-control | 0.98 (0.53, 1.81) | 0%    | Caini et al. 2016   |
| Diffuse large B-cell lymphoma                            | 3                 | Prospective + case-control | 1.49 (1.08, 2.06) | 8,9%  | Wang et al. 2016    |
| Esophageal squamous cell                                 | 2                 | Prospective                | 0.80 (0.48, 1.33) | 62,7% | Li et al. 2016      |
| Multiple Myeloma                                         | 3                 | Prospective + case-control | 1.08 (0.46, 2.54) | 64%   | Caini et al. 2016   |
| Non-Hodgking lymphoma                                    | 8                 | Prospective + case-control | 1.12 (0.90, 1.38) | 61%   | Caini et al. 2016   |
| Ovarian Cancer                                           | 8                 | Prospective + case-control | 0.87 (0.68, 1.10) | 73,1% | Larsson et al. 2006 |
| <b>Cheese</b>                                            |                   |                            |                   |       |                     |
| Bladder Cancer                                           | 3                 | Prospective + case-control | 0.96 (0.68, 1.24) | 54,8% | Mao et al. 2011     |
| Chronic lymphocytic leukaemia/Small lymphocytic lymphoma | 3                 | Prospective + case-control | 1.28 (0.60, 2.74) | 36%   | Caini et al. 2016   |
| Diffuse large B-cell lymphoma                            | 3                 | Prospective + case-control | 0.93 (0.63, 1.37) | 0%    | Wang et al. 2016    |
| Gastic cancer                                            | 2                 | Prospective                | 1.02 (0.66, 1.58) | 0%    | Tian et al. 2014    |
| Multiple Myeloma                                         | 3                 | Prospective + case-control | 0.94 (0.36, 2.41) | 67%   | Caini et al. 2016   |
| Non-Hodgking lymphoma                                    | 1                 | Prospective                | 1.09 (0.85, 1.39) | NA    | Wang et al. 2016    |
| <b>Butter</b>                                            |                   |                            |                   |       |                     |
| Bladder Cancer                                           | 3                 | Prospective + case-control | 1.19 (0.81, 1.58) | 59,5% | Mao et al. 2011     |
| Non-Hodgking lymphoma                                    | 4                 | Prospective + case-control | 1.31 (1.04, 1.65) | 36,9% | Wang et al. 2016    |
| <b>Yogurt</b>                                            |                   |                            |                   |       |                     |
| Diffuse large B-cell lymphoma                            | 3                 | Prospective + case-control | 0.90 (0.67, 1.21) | 0%    | Wang et al. 2016    |
| Ovarian Cancer                                           | 2                 | Prospective                | 0.95 (0.69, 1.30) | 0%    | Larsson et al. 2006 |
| *result for dose-response analysis                       |                   |                            |                   |       |                     |

Supplementary Table 4. Variables investigated to address the strength of evidence from selected meta-analyses on dairy (total and individual foods) consumption and health outcomes.

| Outcome                 | Heterogeneity | Dose-response analysis | Agreement over time | Potential confounding | Reference                  |
|-------------------------|---------------|------------------------|---------------------|-----------------------|----------------------------|
| <b>Total dairy</b>      |               |                        |                     |                       |                            |
| Cancer (breast)         | ⊗             | ⊕                      | ⊕                   | ⊕                     | Zang et al. 2015           |
| Cancer (colorectum)     | ⊗             | ⊕                      | ○                   | ⊗                     | Aune et al. 2012           |
| Cancer (lung)           | ⊕             | ○                      | ⊕                   | ○                     | Yu et al. 2016             |
| Cancer (NHL)            | ⊗             | ○                      | ○                   | ○                     | Wang et al. 2016           |
| Cancer (prostate)       | ⊗             | ○                      | ⊗                   | ⊕                     | Aune et al. 2015           |
| Cancer (stomach)        | ⊗             | ○                      | ⊕                   | ○                     | Sun et al. 2014            |
| CHD                     | ⊕             | ⊕                      | ⊕                   | ○                     | Qin et al. 2015            |
| CVD                     | ⊗             | ○                      | ⊗                   | ○                     | Qin et al. 2015            |
| Elevated blood pressure | ⊗             | ○                      | ○                   | ○                     | Ralston et al. 2012        |
| Hypertension*           | ⊗             | ⊕                      | ○                   | ⊗                     | Soedamah-Muthu et al. 2012 |
| Metabolic syndrome      | ⊗             | ⊕                      | ⊕                   | ⊕                     | Kim et al. 2016            |
| Mortality (cancer)      | ⊗             | ○                      | ○                   | ⊗                     | Lu et al. 2016             |
| Mortality (CVD)         | ⊗             | ○                      | ○                   | ○                     | O'Sullivan et al. 2013     |
| Parkinson's disease     | ⊗             | ○                      | ⊕                   | ⊕                     | Jiang et al. 2014          |
| Stroke (hemorrhagic)    | ⊕             | ⊕                      | ○                   | ○                     | Hu et al. 2014             |
| Stroke (ischaemic)      | ⊕             | ⊕                      | ○                   | ○                     | Hu et al. 2014             |
| Stroke (mortality)      | ⊗             | ⊕                      | ○                   | ○                     | Hu et al. 2014             |
| Stroke (total)          | ⊕             | ○                      | ⊕                   | ⊕                     | Hu et al. 2014             |
| T2DM                    | ⊗             | ⊕                      | ⊕                   | ⊕                     | Aune et al. 2013           |
| <b>Milk</b>             |               |                        |                     |                       |                            |
| Cancer (bladder)        | ⊗             | ○                      | ○                   | ○                     | Li et al. 2011             |
| Cancer (breast)         | ⊕             | ○                      | ⊕                   | ⊗                     | Wu et al. 2016             |
| Cancer (colon)          | ○             | ○                      | ○                   | ○                     | Huncharek et al. 2009      |
| Cancer (colorectum)     | ⊗             | ⊕                      | ○                   | ⊕                     | Aune et al. 2012           |
| Cancer (lung)           | ⊕             | ○                      | ⊕                   | ⊕                     | Yu et al. 2016             |
| Cancer (prostate)       | ⊗             | ○                      | ⊗                   | ⊕                     | Aune et al. 2015           |
| Cancer (stomach)        | ⊗             | ○                      | ⊕                   | ○                     | Sun et al. 2014            |
| CHD                     | ⊗             | ⊕                      | ⊕                   | ⊕                     | Alexander et al. 2016      |
| Cognitive disorders     | ○             | ○                      | ○                   | ○                     | Wu et al. 2016             |
| CVD                     | ⊗             | ○                      | ⊗                   | ○                     | Alexander et al. 2016      |

|                              |   |   |   |   |                              |
|------------------------------|---|---|---|---|------------------------------|
| Elevated blood pressure      | ∅ | ○ | ○ | ○ | Ralston et al. 2012          |
| Hip fracture (men)*          | ∅ | ⊕ | ○ | ○ | Bischoff-Ferrari et al. 2011 |
| Hip fracture (women)*        | ∅ | ⊕ | ○ | ○ | Bischoff-Ferrari et al. 2011 |
| Kidney stones*               | ⊕ | ⊕ | ○ | ○ | Xu et al. 2015               |
| Metabolic syndrome           | ∅ | ○ | ⊕ | ○ | Chen et al. 2015             |
| Mortality (all-cause)        | ∅ | ⊕ | ○ | ○ | O'Sullivan et al. 2013       |
| Mortality (CVD)              | ⊕ | ⊕ | ○ | ⊕ | O'Sullivan et al. 2013       |
| Parkinson's disease          | ∅ | ⊕ | ○ | ○ | Jiang et al. 2014            |
| Stroke (hemorrhagic)         | ⊕ | ⊕ | ○ | ○ | Alexander et al. 2016        |
| Stroke (ischaemic)           | ⊕ | ⊕ | ○ | ○ | Alexander et al. 2016        |
| Stroke (mortality)           | ○ | ⊕ | ○ | ○ | Hu et al. 2014               |
| Stroke (total)               | ○ | ○ | ⊕ | ○ | Alexander et al. 2016        |
| T2DM                         | ⊕ | ⊕ | ⊕ | ∅ | Aune et al. 2013             |
| <b>Yogurt</b>                |   |   |   |   |                              |
| Cancer (breast)              | ∅ | ○ | ∅ | ○ | Wu et al. 2016               |
| Cancer (prostate)            | ⊕ | ⊕ | ○ | ○ | Aune et al. 2015             |
| CHD                          | ∅ | ○ | ⊕ | ○ | Alexander et al. 2016        |
| CVD                          | ∅ | ○ | ○ | ○ | Alexander et al. 2016        |
| Parkinson's disease          | ∅ | ○ | ○ | ○ | Jiang et al. 2014            |
| Stroke                       | ∅ | ○ | ○ | ○ | Qin et al. 2015              |
| T2DM*                        | ⊕ | ⊕ | ⊕ | ⊕ | Aune et al. 2013             |
| <b>Cheese</b>                |   |   |   |   |                              |
| Cancer (breast) <sup>a</sup> | ∅ | ○ | ○ | ○ | Zang et al. 2015             |
| Cancer (colorectum)          | ∅ | ⊕ | ○ | ∅ | Ralston et al. 2014          |
| Cancer (ovarian)             | ⊕ | ○ | ○ | ○ | Larsson et al. 2006          |
| Cancer (prostate)            | ∅ | ⊕ | ∅ | ∅ | Aune et al. 2015             |
| CHD                          | ∅ | ⊕ | ⊕ | ⊕ | Chen et al. 2017             |
| CVD                          | ∅ | ⊕ | ○ | ⊕ | Chen et al. 2017             |
| Elevated blood pressure      | ∅ | ○ | ○ | ○ | Ralston et al. 2012          |
| Mortality (all-cause)        | ∅ | ⊕ | ○ | ○ | O'Sullivan et al. 2013       |
| Mortality (CVD)              | ∅ | ⊕ | ○ | ○ | O'Sullivan et al. 2013       |
| Parkinson's disease          | ∅ | ⊕ | ○ | ○ | Jiang et al. 2014            |
| Stroke (total)               | ∅ | ⊕ | ⊕ | ⊕ | Chen et al. 2017             |
| T2DM                         | ∅ | ⊕ | ○ | ○ | Gao et al. 2013              |
| <b>Butter</b>                |   |   |   |   |                              |
| CHD                          | ∅ | ○ | ○ | ○ | Qin et al. 2015              |
| CVD                          | ∅ | ⊕ | ○ | ○ | Pimpin et al. 2016           |
| Mortality (all-cause)        | ⊕ | ○ | ○ | ○ | O'Sullivan et al. 2013       |
| Stroke                       | ∅ | ⊕ | ⊕ | ○ | Qin et al. 2015              |

|                                        |   |   |   |   |                    |
|----------------------------------------|---|---|---|---|--------------------|
| T2DM*                                  | ∅ | ⊕ | ○ | ○ | Pimpin et al. 2016 |
| <sup>a</sup> include cheese and butter |   |   |   |   |                    |
| * only dose-response meta-analysis     |   |   |   |   |                    |