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Dairy product consumption and risk of cancer: a short report from the NutriNet-Santé prospective cohort study

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Keywords: dairy products; cancer; prospective study; cohort

Abbreviations: BMI, body mass index; CI, confidence interval; GLOBOCAN, Global Cancer Observatory; HR, hazards ratio; IPAQ, International Physical Activity Questionnaire; SD, standard deviation; SFA, saturated fatty acid; WCRF/AICR, World Cancer Research Fund/American Institute of Cancer Research

1 **Abstract**

2 The impact of dairy product consumption for long-term health remains unclear, in particular
3 regarding their involvement in cancer etiology for frequent locations like breast or prostate.
4 Besides, little is known about potentially different effects of dairy product subtypes. Our
5 objective was therefore to evaluate the associations between dairy product consumption (total
6 and subtypes) and cancer risk. A total of 101,279 participants from the French NutriNet-Santé
7 cohort study were included (78.7% women; mean (SD) age=42.2 (14.5) years). Dairy product
8 consumption was assessed using validated web-based 24-hour dietary records. Multi-adjusted
9 Cox models were computed. After a median [interquartile range] follow-up time of 5.9 [2.7-
10 8.3] years, we documented 2,503 incident cancer cases (783 breast, 323 prostate, and 182
11 colorectal cancers). Total dairy product consumption was not significantly associated with
12 cancer. However, the consumption of “fromage blanc” (a French type of quark/cottage
13 cheese) was associated with an increased risk of cancer overall [HR for 1 serving increment
14 (95% CI)=1.11 (1.01-1.21); *P*-trend=0.03] and of colorectal cancer [HR=1.39 (1.09-1.77); *P*-
15 trend<0.01]. Besides, sugary dairy dessert consumption was directly associated with
16 colorectal cancer risk [HR for 1 serving increment=1.58 (1.01-2.46); *P*-trend=0.046]. No
17 association was observed between the consumption of dairy products or sugary dairy desserts
18 and the risk of prostate and breast cancers. In our study, the consumption of dairy products
19 was not associated with the risk of overall, colorectal, breast or prostate cancers. The
20 consumption of “fromage blanc” and sugary dairy desserts were associated to an increased
21 risk of colorectal cancer, but this warrants further investigations.

22 **Introduction**

23 Cancer incidence is rapidly increasing and has become a leading cause of death in many
24 countries. The Global Cancer Observatory (GLOBOCAN) estimated that 18.1 million new
25 cancer cases occurred worldwide in 2018 ¹. There is accumulating evidence that diet and
26 lifestyle factors play an important role on cancer development ². In particular, dairy product
27 consumption may be involved in cancer prevention through their content in calcium, vitamin
28 D, lactic acid-producing bacteria (fermented dairy products), conjugated linoleic acid but also
29 lactoferrin or butyrate ². In 2018, the Third Expert Report from the World Cancer Research
30 Fund/American Institute of Cancer Research (WCRF/AICR) concluded that consuming dairy
31 products probably decreases the risk of colorectal cancer ². Associations with a decreased
32 breast cancer risk (pre-menopause) and an increased prostate cancer risk (potentially through
33 elevated levels of insulin-like growth factor 1) were less clear, with only limited-suggestive
34 evidence ², thus requiring additional studies. Evidence for other cancer locations is more
35 limited ². Besides, more evidence is needed regarding potential specific associations between
36 dairy product subtypes and cancer risk.

37 We therefore analyzed the associations between the consumption of total dairy products and
38 specific dairy product subtypes and the risk of developing overall, breast, prostate and colon
39 cancers in the NutriNet-Santé Cohort Study.

40

41 **Material and methods**

42 *Study population*

43 The NutriNet-Santé study is a French, ongoing, web-based prospective cohort launched in
44 2009 aiming to evaluate the relationship between nutrition, mortality and health outcomes,
45 and examine determinants of dietary behaviors and nutritional status. Detailed information on
46 this cohort can be found elsewhere ³. Participants (aged >18 years old) with access to the

47 Internet have been continuously recruited since May 2009 from the general population by vast
48 multimedia campaigns, and followed through questionnaires using a dedicated and secured
49 online platform (<http://www.etude-nutrinet-sante.fr>). Electronic informed consent was
50 obtained from each participant. The NutriNet-Santé Study (registered at ClinicalTrials.gov as
51 NCT03335644) is conducted according to the Declaration of Helsinki guidelines. It was
52 approved by the Institutional Review Board of the French Institute for Health and Medical
53 Research and the ‘Commission Nationale de l’Informatique et des Libertés’ (CNIL
54 n°908450/n°909216).

55 *Data collection*

56 At baseline, participants completed a set of five validated questionnaires related to
57 sociodemographic and lifestyle characteristics ⁴, anthropometry ^{5,6}, dietary intakes ⁷⁻⁹,
58 physical activity (validated short version of the International Physical Activity Questionnaire
59 [IPAQ]) ¹⁰ and health status. Dietary data were collected at baseline and every six months
60 through series of three non-consecutive validated web-based 24-hour dietary records (2
61 weekdays and 1 weekend day), randomly assigned over a two-week period. Portion sizes were
62 estimated using validated photographs ¹¹, standard containers or directly in g or mL. Mean
63 daily energy, alcohol and macro- and micro-nutrient intakes were estimated using a French
64 food composition database ¹². Amounts consumed from composite dishes were estimated
65 considering French recipes validated by food and nutrition professionals. Dietary under-
66 reporters were detected on the basis of the method proposed by Black ¹³. The present study
67 focused on the consumption of dairy products, which include milk and cheese, as well as
68 yogurt, “fromage blanc” and “petit-Suisse” (French specialties, similar to cottage cheese or
69 quark) with a sugar content < 12%). Fermented dairy products included yogurt, cheese,
70 “fromage blanc” and “petit-Suisse”. Sugary dairy desserts, milk-based products not classified
71 as dairy products according to French recommendations due to their high sugar content (e.g.,

72 cream dessert, pudding, custard, “crème brûlée”, milkshake, as well as sweetened or fruit
73 yogurt, “fromage blanc” and “petit-Suisse” with a sugar content $\geq 12\%$) were also considered.
74 The consumption of dairy products and sugary dairy desserts was assessed as the mean intake
75 over all dietary records that were completed during the first two years of each participant’s
76 follow-up.

77 *Case ascertainment*

78 Participants were asked to report their health status at baseline and every six months through a
79 health check-up questionnaire. A dedicated and secured web-interface is also available at any
80 time for the participants to report health events, new treatments, or medical exams. Reported
81 cancer cases were validated by an expert medical committee, based on medical and
82 anatomopathological reports collected from the participants, their physicians and/or hospitals.
83 The NutriNet-Santé study is also linked to the national medical databases of the health
84 insurance (SNIIRAM) and to the French cause-specific mortality registry (CépiDC) enabling
85 to complete death and health data thereby limiting potential bias due to unreported cancer
86 cases. Cancer cases were classified using the International Chronic Diseases Classification,
87 10th Revision, Clinical Modification (ICD-10) ¹⁴. All primary cancers diagnosed between the
88 inclusion and January 7th, 2019 were considered as cases, except for basal cell skin
89 carcinoma.

90 *Statistical analysis*

91 A total of 129,787 individuals provided at least 2 24h dietary records during their first two
92 years of follow-up, of which were excluded n=21,804 energy under-reporters and n=6,704
93 participants with prevalent cancer at baseline. Dairy product consumption was considered
94 using standard servings: 150 g of milk; 125 g of yogurt; 30 g of cheese; 100 g of “fromage
95 blanc”; 120 g of “petit-Suisse” and 125 g of sugary dairy dessert. Servings for total dairy
96 products were calculated as the sum of the servings of milk, cheese, yogurt, “fromage blanc”,

97 and “petit-Suisse”. Dairy desserts were considered separately. Hazards ratios and 95%
98 confidence intervals were computed from Cox proportional hazard models. Main outcomes
99 were overall, breast, prostate and colorectal cancers (the most common cancer locations in the
100 cohort). Participants contributed person-time from their inclusion until their date of diagnosis,
101 last completed questionnaire, death, or January 7th, 2019, whichever occurred first.
102 Stratifications by menopausal status for breast cancer were also carried out. In these analyses,
103 women contributed person-time to the premenopausal model until their age at menopause, and
104 to the postmenopausal model from their age at menopause.

105 The main model included the following potential confounders: sociodemographic
106 characteristics – age (timescale), sex, educational level (less than high-school degree, high-
107 school degree, undergraduate and graduate degree); anthropometric characteristics – height
108 (cm), BMI (kg/m²); lifestyle – smoking status (never, former, current smokers), physical
109 activity (high, moderate, low, missing); personal and family history of diseases (yes/no) –
110 personal history of type 2 diabetes, hypertriglyceridemia, hypercholesterolemia and family
111 history of cancer; study design (number of 24-hour dietary records); dietary intakes of
112 nutrients or food groups associated with cancer risk or reflecting overall diet quality: non-
113 alcohol energy (kcal/d), sugar (g/d), sodium (g/d), alcohol (g/d), fruit and vegetables (g/d),
114 whole grain products (g/d), red and processed meat (g/d) as well as saturated fatty acids
115 (SFAs) (g/d, continuous) and calcium (mg/d) brought by other sources than dairy products.
116 For analyses on dairy product subtypes, models were also adjusted for the consumption of
117 each other dairy products than the one studied. Breast cancer models were additionally
118 adjusted for covariates linked to reproductive history: menopausal status at baseline (yes/no),
119 use of hormonal treatment for menopause (yes/no), oral contraception use (yes/no), number of
120 children (continuous), age at menarche (never, <12y, ≥12y), and age at first birth (never,
121 <30y, ≥30y).

122 For all covariates except physical activity, $\leq 5\%$ of values were missing and imputed to the
123 modal (categorical variables) or median (continuous variables) values. A missing class was
124 created for physical activity (14% missing). We conducted secondary analyses to examine the
125 associations between sex-specific quartiles of intake of SFAs and calcium from dairy products
126 and the risk of cancer. Sensitivity analyses were performed excluding participants with less
127 than two years of follow-up and repeating the main analyses with a model not adjusted for
128 dietary variables or personal health history.

129 All tests were two-sided, with $P < 0.05$ considered to be statistically significant. We used SAS
130 version 9.4 for the analyses.

131 **Results**

132 A total of 101,279 participants (78.7% women) with a median [interquartile range] follow-up
133 time of 5.9 [2.7-8.3] years were included in the analyses. During follow-up, we documented
134 the incidence of 2,503 overall cancers, 783 breast cancers (324 premenopausal and 459
135 postmenopausal), 323 prostate cancers and 182 colorectal cancers. Participants consumed on
136 average 198.4 g/day of dairy products, with 83.3g/day of milk, 58.1g/day of yogurt, 36.9g/day
137 of cheese and 17.7g/day of “fromage blanc”.

138 Table 1 contains the baseline characteristics of all participants according to sex-specific
139 quartiles of total dairy product consumption. At baseline, mean (SD) age was 42.2 (14.5)
140 years and mean (SD) BMI was 23.7 (4.5) kg/m². Individuals with a higher consumption of
141 total dairy products were more likely to have higher BMI and family history of cancer, to be
142 current smokers and physically active. They also showed significantly higher intakes of
143 energy (without alcohol), total lipids, carbohydrates and sodium and lower intakes of alcohol
144 and sugary dairy desserts.

145 No association was observed between the consumption of total dairy products and the risk of
146 overall cancer, and neither with the risk of breast cancer (with similar results pre and post-
147 menopause), colorectal cancer and prostate cancer (Table 2).

148 Likewise, no association was observed for the consumption of milk, yogurt or cheese.

149 However, an increase of 1 serving in the consumption of “fromage blanc” was associated with
150 an increased risk of overall cancer [HR (95% CI)=1.11 (1.01-1.21); *P* for trend=0.03] and
151 colorectal cancer [HR=1.39 (1.09-1.77); *P* for trend<0.01] but not with breast or prostate
152 cancer risk (Table 2). Similarly, 1-serving increment in sugary dairy dessert consumption was
153 positively associated with the risk of colorectal cancer [HR=1.58 (1.01-2.46); *P* for
154 trend=0.046] (Table 2).

155 In line, no association was observed between intakes of SFAs and calcium from dairy product
156 sources and cancer risk (Table 3).

157 The results of the sensitivity analyses (Supplementary Table S1) for overall, colorectal and
158 prostate cancer were similar to the main results.

159

160 **Discussion**

161 In the present study, no association was observed between the consumption of dairy products
162 and the risk of overall, colorectal, breast or prostate cancers. The consumption of “fromage
163 blanc” and sugary dairy desserts were however associated with higher risk of colorectal
164 cancer.

165 Our results were in line with a recent meta-analysis showing that there were no strong
166 associations between the intake of milk or yogurt and breast cancer risk ¹⁵. Additionally,
167 although some studies indicated that the consumption of milk and dairy products may increase
168 the risk of prostate cancer, the evidence remains inconsistent ¹⁶. However, unlike our findings,
169 previous studies have shown a significant decreased colorectal cancer risk associated with the

170 consumption of total dairy products ¹⁷, supporting the conclusions of the WCRF/AICR
171 (although the association with cheese consumption was less clear) ², as well as an overall
172 decrease in cancer risk related to fermented dairy food intake ¹⁸. Differences between these
173 studies and ours could pertained to differences in the amount and types of dairy products
174 consumed but also differences in overall lifestyle between the population studied.

175 No clear mechanisms seem to explain the observed increased risk of colorectal cancer
176 associated with the consumption of “fromage blanc”, a dairy specialty resulting from lactic
177 coagulation and draining, without further processing or additives. Thus, we suggest
178 interpreting this result with caution, as it could result from an artefact of the study sample.
179 The consumption of “fromage blanc” in France is often encouraged as part of dieting. Hence,
180 individuals consuming higher amounts of “fromage blanc” (more likely to have a higher BMI,
181 family history of cancer and higher prevalence of type 2 diabetes in our sample) may be those
182 already at higher risk of cancer, thus introducing a bias in the observed association, even
183 though we adjusted for personal history of diseases and family history of cancer in our main
184 model and excluded cases occurring during the first years of follow-up in sensitivity analyses.
185 In turn, sugary dairy desserts often contain elevated amounts of sugar as well as additives (for
186 instance emulsifiers or texturizers) ^{19,20}, which could contribute to explain the observed
187 association with an increased colorectal cancer risk, notably through body weight gain and
188 subsequent increase in insulin resistance ².

189 This study has some limitations that should be acknowledged. First, since this is a volunteer-
190 based cohort, participants in the NutriNet-Santé cohort were more often women, with health-
191 conscious behaviors and with higher educational and socioeconomical status in comparison to
192 the general French population ²¹. This could limit the generalization of our results as it may
193 have resulted in a lower number of incident cancer cases and a lower consumption of sugary
194 dairy desserts, which could have led to underestimate the strength of the associations

195 observed. Secondly, the number of incident colorectal cancer cases was relatively limited,
196 which may have prevented us from observing an association for total dairy consumption ².
197 Statistical power was also limited by the fact that there was a substantial proportion of non-
198 consumers for several dairy subtypes. Next, despite the multiple adjustments in our analyses,
199 residual confounding or bias cannot be ruled out. Finally, dietary assessment tools are subject
200 to some measurement error. Yet, to limit this bias, dietary intakes in this study were assessed
201 using repeated 24h dietary records (mean number of dietary records per participant of 5.7
202 (SD: 3.1)) that have been validated against biomarkers and interviews by a trained dietitian ⁷⁻
203 ⁹.

204 Overall, our analyses did not show evidence of a statistically significant association between
205 dairy product intake and cancer risk. The results suggest a positive modest association
206 between the consumption of “fromage blanc” and sugary dairy desserts and colorectal cancer
207 risk. However, this requires additional investigation in further prospective studies and more
208 mechanistic insights.

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Authors’ contribution: The authors’ contributions were as follows – MDT, LBP, NEBS, LSS, MT conceptualized the study and defined the analytical strategy; LBP: performed statistical analyses and drafted the manuscript; MDT, MT: supervised statistical analyses;

MDT, NEBS, LSS, MT: supervised writing; LS, CD, BS, EC, GWF, SH, PG, EKG, CJ: critically helped in the interpretation of results, read and revised the manuscript and provided relevant intellectual input. They all read and approved the final manuscript. MDT and MT had primary responsibility for the final content.

Data availability statement: If you are a researcher of a public institution, you can submit a collaboration request including your institution and a brief description of your project to collaboration@etude-nutrinet-sante. All requests will be reviewed by the steering committee of the NutriNet-Santé study. A financial contribution may be requested. If the collaboration is accepted, a data access agreement will be necessary and appropriate authorizations from the competent administrative authorities may be needed. In accordance with existing regulations, no personal data will be accessible.

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Conflict of interest: Dr Nancy Babio declares that her institution received grants from Danone S.A. for the purposes of scientific and technical consulting but not for preparing this study. In addition, she was one of the members of the Scientific Advisory Board of the EU program for the promotion of milk and milk products within the framework of appropriate dietary practices (2017-2019). Jordi Salas was a member of the executive committee of the Instituto Danone España. He is currently an unpaid member of the Danone Institute España and the Danone International Institute and declares he has received funds to cover the

expenses derived from the Institute but not for this study. All other authors declare no conflict of interest.

Ethics Statement: Electronic informed consent was obtained from each participant. The NutriNet-Santé Study (registered at ClinicalTrials.gov as NCT03335644) is conducted according to the Declaration of Helsinki guidelines. It was approved by the Institutional Review Board of the French Institute for Health and Medical Research and the ‘Commission Nationale de l’Informatique et des Libertés’ (CNIL n°908450/n°909216).

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Table 1. Baseline characteristics of study population according to quartiles of dairy products consumption ($n=101,279$). NutriNet-Santé cohort, France, 2009-19^a

Characteristics	All participants ($n=101,279$)	Quartiles of total dairy product consumption				P-value ^a
		1 ($n=25,319$)	2 ($n=25,320$)	3 ($n=25,319$)	4 ($n=25,321$)	
Age (years)	42.2 (14.5)	41.2 (14.2)	43.0 (14.4)	43.1 (14.6)	41.6 (14.5)	<0.001
Female sex, n (%)	79,742 (78.7)	19,935 (19.7)	19,936 (19.7)	19,935 (19.7)	19,936 (19.7)	-
Height (cm)	166.7 (8.0)	166.6 (8.0)	166.6 (8.1)	166.7 (8.0)	167.0 (8.1)	<0.001
BMI (Kg/m ²)	23.7 (4.5)	23.1 (4.2)	23.6 (4.4)	24.0 (4.5)	24.1 (4.7)	<0.001
Family history of cancer ^b , n (%)	37,550 (37.1)	9,054 (8.9)	9,617 (9.5)	9,679 (9.6)	9,200 (9.1)	<0.001
Higher education						
No	17,279 (17.1)	4,138 (4.1)	4,344 (4.3)	4,354 (4.3)	4,443 (4.4)	<0.001
Yes, <2 years	17,311 (17.1)	4,379 (4.3)	4,224 (4.2)	4,268 (4.2)	4,440 (4.4)	
Yes, ≥2 years	66,689 (65.9)	16,802 (16.6)	16,752 (16.5)	16,697 (16.5)	16,438 (16.2)	
Smoking status, n (%)						
Never	17,516 (17.3)	5,709 (5.6)	4,634 (4.6)	3,889 (3.8)	3,284 (3.2)	<0.001
Former	32,816 (32.4)	7,978 (7.9)	8,438 (8.3)	8,604 (8.5)	7,796 (7.7)	
Current	50,947 (50.3)	11,632 (11.5)	12,248 (12.1)	12,826 (12.7)	14,241 (14.1)	
IPAQ physical activity level, n (%)						
High	28,154 (27.8)	6,809 (6.7)	6,936 (6.9)	7,180 (7.1)	7,229 (7.1)	<0.001
Moderate	37,587 (37.1)	9,466 (9.4)	9,631 (9.5)	9,421 (9.3)	9,069 (9.0)	
Low	21,422 (21.2)	5,629 (5.6)	5,310 (5.2)	5,188 (5.1)	5,295 (5.2)	
Missing	14,116 (13.9)	3,415 (3.4)	3,443 (3.4)	3,530 (3.5)	3,728 (3.7)	
Energy intake without alcohol (kcal/d)	1850,3 (452.1)	1748,1 (429.5)	1832,2 (426.3)	1870 (441.1)	1950,8 (485.3)	<0.001
Alcohol intake (g/d)	7.7 (11.8)	8.9 (13.4)	8.8 (12.4)	7.6 (11.1)	5.8 (9.7)	<0.001
Total lipid intake (g/d)	81.6 (25.3)	79.2 (24.3)	82.6 (24.3)	82.3 (25.1)	82.5 (27.2)	<0.001
Carbohydrate intake (g/d)	198.7 (57.6)	188.8 (57.7)	194.6 (53.7)	200 (55.0)	211,2 (61.1)	<0.001
Protein intake (g/d)	78.8 (21.5)	68.9 (19.5)	76.3 (19.0)	80.8 (19.4)	89.2 (22.6)	<0.001
Sodium intake, (mg/d)	2718,9 (885,3)	2,557 (875.7)	2734,3 (865.4)	2772,5 (878,6)	2811,8 (900)	<0.001
Number of children ^c	1.3 (1.2)	1.2 (1.2)	1.3 (1.2)	1.3 (1.2)	1.3 (1.3)	<0.001
Menopausal status at baseline ^c						
Premenopausal, n (%)	57,187 (71.7)	14,847 (18.6)	13,925 (17.5)	13,763 (17.3)	14,652 (18.4)	<0.001
Perimenopausal or postmenopausal, n (%)	22,555 (28.3)	5,088 (6.4)	6,011 (7.5)	6,172 (7.7)	5,284 (6.6)	
Use of hormonal treatment for menopause ^c , n (%)	4,011 (17.9)	822 (3.7)	988 (4.4)	1,153 (5.1)	1,048 (4.7)	<0.001
Oral contraception ^c , n (%)	22,475 (28.2)	5,472 (6.9)	5,366 (6.7)	5,524 (6.9)	6,113 (7.7)	<0.001
Total dairy product consumption ^d (g/d)	198.4 (148.8)	46.5 (26.1)	125.8 (22.1)	215.7 (32.4)	405.4 (121.8)	-
Milk consumption ^e (g/d)	83.3 (122.3)	5.9 (12.1)	25.0 (34.6)	69.7 (69.9)	232.6 (147.4)	-
Yogurt consumption ^f (g/d)	58.1 (68.9)	9.2 (16.7)	45.5 (39.0)	79.8 (61.9)	98.0 (93.6)	-
Cheese consumption ^g (g/d)	36.9 (28.0)	27.4 (20.4)	40.5 (27.4)	41.0 (29.6)	38.6 (31.2)	-
“Fromage blanc” ^h consumption (g/d)	17.7 (40.2)	3.4 (10.1)	12.9 (23.3)	22.3 (36.8)	32.1 (63.4)	-
Fermented dairy products consumption ⁱ (g/d)	115.8 (87.1)	40.7 (25.3)	101.4 (36.8)	147.0 (67.0)	174 (116.9)	-
Sugary dairy desserts consumption ^j (g/d)	36.3 (48.6)	36.9 (53.0)	37.6 (47.1)	35.3 (46.0)	35.3 (47.8)	-
Dairy SFA intake (g/d)	7.9 (5.1)	4.9 (3.5)	7.9 (4.5)	8.8 (5.0)	9.8 (5.7)	-
Dairy calcium intake (mg/d)	432.2 (248.9)	199.4 (134.5)	361.2 (150.6)	477.5 (166.1)	690.6 (226.6)	-

Abbreviations: BMI, body mass index; IPAQ, International Physical Activity Questionnaire; SFA, saturated fatty acids.

^aP-values were obtained using Chi-square tests (categorical variables) or Fisher tests from unadjusted analysis of variance models (continuous variables).

^bAmong first-degree relatives.

^cAmong women.

^dincludes milk, cheese, yogurt, “fromage blanc” and “petit-Suisse”.

^eincludes all mammalian milks including flavored milks (≤12% of the content in simple sugars).

^fincludes all yogurts made with mammalian milk (≤12% of the content in simple sugars).

^galso comprises low-fat cheeses.

^hFrench dairy specialty, similar to cottage cheese/quark (≤12% of the content in simple sugars).

ⁱincludes cheese, yogurt, “fromage blanc”, “petit-Suisse” and fermented milk.

^jincludes cream dessert, pudding, custard, milk shakes, flavored milks, as well as fruit or sweetened yogurt, “fromage blanc” and “petit-Suisse” with ≥12% of the content in simple sugars.

Table 2. Associations between total dairy product and dairy product subtypes consumption and risk of cancer ($n=101,279$). NutriNet-Santé cohort, France, 2009-19^a

	All cancers		Breast cancer		Colorectal cancer		Prostate cancer	
	Continuous per 1 serving increment ^b		Continuous per 1 serving increment		Continuous per 1 serving increment		Continuous per 1 serving increment	
	HR (95% CI)	<i>P</i> value for trend	HR (95% CI)	<i>P</i> value for trend	HR (95% CI)	<i>P</i> value for trend	HR (95% CI)	<i>P</i> value for trend
Cases/person-years (<i>n</i>)	2,503/555,386	-	783/435,186	-	182/555,386	-	323/120,200	
Total dairy ^c :	1.02 (0.98-1.05)	0.30	1.00 (0.93-1.06)	0.87	1.05 (0.93-1.19)	0.45	1.00 (0.91-1.09)	0.95
Milk ^d :	1.01 (0.96-1.07)	0.70	0.97 (0.88-1.07)	0.56	0.92 (0.74-1.15)	0.45	1.07 (0.94-1.23)	0.30
Yogurt ^e	0.99 (0.92-1.07)	0.74	1.02 (0.89-1.16)	0.82	0.90 (0.67-1.19)	0.45	1.03 (0.83-1.29)	0.77
Cheese ^f :	1.02 (0.96-1.07)	0.57	0.99 (0.89-1.10)	0.88	1.10 (0.93-1.30)	0.29	0.92 (0.80-1.05)	0.22
“Fromage blanc” ^g :	1.11 (1.01-1.21)	0.03	1.06 (0.90-1.24)	0.48	1.39 (1.09-1.77)	0.008	1.01 (0.77-1.34)	0.93
Fermented dairy products ^h :	1.02 (0.98-1.06)	0.32	1.01 (0.93-1.09)	0.83	1.10 (0.96-1.27)	0.17	0.95 (0.85-1.06)	0.37
Sugary dairy desserts ⁱ :	1.00 (0.88-1.14)	0.99	1.03 (0.82-1.29)	0.83	1.58 (1.01-2.46)	0.046	0.73 (0.49-1.07)	0.11

Abbreviations: CI, confidence interval; HR, hazard ratio.

^aCox proportional hazard models adjusted for age (timescale), sex (in models for overall and colorectal cancer only), height, BMI, baseline type 2 diabetes, prevalent hypertriglyceridemia, prevalent hypercholesterolemia, energy intake without alcohol, sugar intake, sodium intake, fruits and vegetables intake, whole foods, red and processed meat consumption, non-dairy calcium intake, non-dairy SFA intake, alcohol intake, number of 24 h dietary records, smoking status, educational level, physical activity, and family history of cancer. Breast cancer models were additionally adjusted for menopausal status, use of hormonal treatment for menopause, oral contraception use, number of children, age at menarche, and age at first birth. For analyses on dairy product subtypes, models were also adjusted for the consumption of each other dairy products than the one studied.

^bIntakes in g/day were converted into servings/day based on the use of standard units: 150 g for milk, 125 g for yogurt, 30 g for cheese, 100 g for “fromage blanc”, and 120 g for “petit-Suisse”. Servings for total dairy products were calculated as the sum of the servings of milk, cheese, yogurt, “fromage blanc”, and “petit-Suisse”. Servings for fermented dairy products were calculated as the sum of the servings of cheese, yogurt, “fromage blanc”, “petit-Suisse” and fermented milk. For sugary dairy desserts, we considered the same serving size as yogurt (125 g).

^cincludes milk, cheese, yogurt, “fromage blanc” and “petit-Suisse”.

^dincludes all mammalian milks including flavored milks ($\leq 12\%$ of the content in simple sugars).

^eincludes all yogurts made with mammalian milk ($\leq 12\%$ of the content in simple sugars).

^falso comprises low-fat cheeses.

^gFrench dairy specialty, similar to cottage cheese/quark ($\leq 12\%$ of the content in simple sugars).

^hincludes cheese, yogurt, “fromage blanc”, “petit-Suisse” and fermented milk.

ⁱincludes cream dessert, pudding, custard, milk shakes, flavored milks, as well as fruit or sweetened yogurt, “fromage blanc” and “petit-Suisse” with $\geq 12\%$ of the content in simple sugars).

Table 3. Associations between SFAs and calcium from dairy product intakes and risk of cancer ($n=101,279$). NutriNet-Santé cohort, France, 2009-19^a

Cancer site	All cancers		Breast cancer		Colorectal cancer		Prostate cancer	
	Continuous per 1 SD increment ^b		Continuous per 1 SD increment		Continuous per 1 SD increment		Continuous per 1 SD increment	
	HR (95% CI)	<i>P</i> value for trend	HR (95% CI)	<i>P</i> value for trend	HR (95% CI)	<i>P</i> value for trend	HR (95% CI)	<i>P</i> value for trend
Cases/person-years (<i>n</i>)	2,503/555,386	-	783/435,186	-	182/555,386	-	323/120,200	
SFAs from dairy products:	1.01 (0.96-1.06)	0.65	1.04 (0.94-1.15)	0.46	1.11 (0.95-1.30)	0.20	0.89 (0.78-1.01)	0.08
Calcium from dairy products:	1.02 (0.97-1.07)	0.51	0.97 (0.88-1.06)	0.44	1.07 (0.90-1.27)	0.47	0.99 (0.87-1.12)	0.04

Abbreviations: BMI, body mass index; CI, confidence interval; HR, hazard ratio; SD, standard deviation; SFA, saturated fatty acid.

^aCox proportional hazard models adjusted for age (timescale), sex (in models for overall and colorectal cancer only), height, BMI, baseline type 2 diabetes, prevalent hypertriglyceridemia, prevalent hypercholesterolemia, energy intake without alcohol, sugar intake, sodium intake, fruits and vegetables intake, whole foods, red and processed meat consumption, non-dairy calcium intake, non-dairy SFA intake, alcohol intake, number of 24 h dietary records, smoking status, educational level, physical activity, and family history of cancer. Breast cancer models were additionally adjusted for menopausal status, use of hormonal treatment for menopause, oral contraception use, number of children, age at menarche, and age at first birth.

^bHRs are given for an increase of 1 SD in intake (SD:5.09 g/d for SFAs from dairy products, and 248.9 mg/d for calcium from dairy products).