

Differentiated thyroid carcinoma in French Polynesia: Impact of atmospheric nuclear tests performed by France

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Background : France performed 41 atmospheric nuclear tests in French Polynesia (FP) between 1966 and 1974

Objective : to assess the role of radioactive fallouts on the risk of differentiated thyroid cancer (DTC) in FP general population

Methods : Case-control study including most of DTC diagnosed in FP between 1984 and 2016 + Thyroid radiation dose estimation using reports declassified by French Army in 2013 + Risk projection using BEIR VII model

Conclusion : Low impact / case-control study significant only if excluding non-invasive micro-carcinoma / Risk projection : 29 (8 to 97) DTC due to nuclear tests

Case-control study Description of subjects

Characteristic	Thyroid cancer cases (395)	Controls (555)	P-value*
Women (n, %)	336 (85.1%)	473 (85.2%)	**
Mean age at end of follow-up (years)	43.6	42.3	**
Parents Ethnical origin (n, %)			
Both polynesian	219 (55.6%)	283 (51.0%)	
Polynesian- Asian	57 (14.5%)	76 (13.7%)	0.09
Polynesian-European	71 (18.0%)	103 (18.6%)	
Polynesian-Asian-European	34 (8.6%)	47 (8.5%)	
Other	14 (3.5%)	76 (13.7%)	
Familial history of thyroid cancer (n, %)	20 (5.1%)	9 (1.6%)	0.006
Familial history of thyroid pathology (n, %)	155 (39.2%)	96 (17.3%)	<0.0001
Personal history of radiation therapy (n, %)	34 (8.6%)	5 (0.9%)	<0.0001
Archipelago of birth (n, %)			
Tahiti & Moorea	223 (56.5%)	328 (59.1%)	
Other Société islands	80 (20.2%)	102 (18.4%)	0.8
Australes	25 (6.3%)	30 (5.4%)	
Marquesas	18 (4.6%)	18 (4.9%)	
Tuamotu-Gambier	49 (12.4%)	49 (12.3%)	

* Univariate conditional logistic regression

** Matching criteria

Case-control study : association with thyroid radiation dose received before age 15

Exposure	Total population, matched analysis (395 cases and 555 controls)			Excluding unifocal micro carcinomas size and their controls, matched analysis (258 cases / 359 controls)			Excluding unifocal micro carcinomas, unmatched analysis, stratified on study, sex and age (258 cases / 555 controls)		
	Cases/ Controls	OR(95%CI)	p-value	Cases/ Controls	OR (95%CI)	p-value	Cases/ Controls	OR (95%CI)	p-value
Thyroid dose before age 15									
Unknown	5/13	0.4 (0.1 ; 1.4)		3/10			3/13		
<1 mGy	323/451	1*		202/286	1*		202/451	1*	
1– 9.9 mGy	48/74	1.3 (0.6 ; 2.7)	0.18	35/54	1.5 (0.6 ; 3.9)	0.11	35/74	1.5 (0.8 ; 2.7)	0.04
10 – 19.9 mGy	15/13	2.0 (0.5 ; 8.1)		14/7	4.7 (0.8 ; 28)		14/13	2.5 (0.9 ; 6.6)	
20 – 39 mGy	4/5	5.3 (0.3 ; 23)		4/2	16.7 (0.6;4569)		4/4	3.6 (0.7 ; 18)	
Linear	0.078 (-0.10; 0.26)		0.15	0.17 (-0.021-0.54)			0.05	0.069 (-0.041 ; 0.18)	0.06
Exponential	0.070 (-0.011 ; 0.15)		0.08	0.13 (0.029-0.23)			0.009	0.051 (0.0025 ; 0.10)	0.03
Quadratic	0.0092 (-0.0076 ; 0.026)		0.06	0.023 (-0.016 ; 0.061)			0.007	0.0057 (-0.0023 ; 0.014)	0.03

Case-control study : Other risk factors

Characteristic	Thyroid cancer cases (395)	Controls (555)	P-value*
Average height in m (std)			
Women	1.65 (0.06)	1.64 (0.06)	0.001
Men	1.76 (0.07)	1.74 (0.07)	
Mean weight at end follow-up in kg (std)			
Women	84 (21)	75 (19)	<0.0001
Men	103 (23)	91 (19)	
Mean BMI at end follow-up (std)			
Women	30.7 (7.3)	27.9 (6.9)	<0.0001
Men	33.3 (6.9)	30.0 (5.9)	
Diploma (n, %)			
No	161 (40.8%)	197 (35.5%)	0.03
Yes	234 (59.2%)	358 (64.5%)	
Insufficient dietary intake (n, %)			
No	282 (39.8%)	427 (60.2%)	
Yes	113 (46.9%)	128 (53.1%)	0.05
Number of pregnancies (n, %)			
0	40 (11.9%)	67 (14.2%)	
1-4	162 (48.2%)	264 (55.8%)	0.002
5-16	134 (39.9%)	142 (30.0%)	

* Univariate conditional logistic regression

** Matching criteria

Case-control study : source of irradiation

Table 3 –Characteristics of the thyroid dose due to atmospheric nuclear tests: subjects born in or before 1974, and who were present in French Polynesia at the time of the tests		
	Thyroid cancer cases (n=337)	Controls (n=441)
Dose in mGy mean, median (min-max)		
Lifetime dose		
Whole sample	4.71; 3.47 (<0.01-36.25)	4.60; 3.65 (<0.01-31.19)
Gender		
Male	4.32; 3.28 (<0.01-17.89)	4.29; 3.27 (<0.01-22.15)
Female	4.77; 3.54 (<0.01-36.25)	4.65; 3.66 (<0.01-31.19)
Source		
Leafy vegetables	3.28; 2.59 (<0.01-23.01)	3.30; 2.55 (<0.01-29.63)
Fresh cow's milk*	0.58; 0.02 (<0.01-17.65)	0.56; 0.09 (<0.01-8.92)
Inhalation	0.22; 0.16 (<0.01-4.64)	0.19; 0.16 (<0.01-1.63)
Cistem drinking water	0.16; <0.01 (<0.01-6.52)	0.11; <0.01 (<0.01-5.64)
Other foodstuffs	0.04; 0.02 (<0.01-0.35)	0.05; 0.02 (<0.01-0.94)
External irradiation	0.43; 0.43 (<0.01-5.81)	0.39; 0.44 (<0.01-3.5)
Dose received before the age of 15		
Whole sample	2.93; 1.30 (<0.01-36.15)	2.71; 1.50 (<0.01-31.19)
Gender		
Male	2.61; 1.16 (<0.01-17.89)	2.15; 1.03 (<0.01-11.87)
Female	2.99; 1.32 (<0.01-36.15)	2.81; 1.56 (<0.01-31.19)
Source		
Leafy vegetables	1.95; 0.92 (<0.01-23.01)	1.84; 0.87 (<0.01-29.63)
Fresh cow's milk*	0.43; <0.01 (<0.01-17.65)	0.42; 0 (<0.01-8.92)
Inhalation	0.16; 0.06 (<0.01-4.64)	0.13; 0.07 (<0.01-0.75)
Cistem drinking water	0.13; <0.01 (<0.01-6.52)	0.09; <0.01 (<0.01-5.64)
Other foodstuffs	0.02; <0.01 (<0.01-0.24)	0.02; <0.01 (<0.01-0.29)
External irradiation	0.25; 0.09 (<0.01-5.8)	0.22; 0.10 (<0.01-2.25)

* Only in Tahiti

Risk projection

- Lifetime attributable risk predicted in the whole native population present in FP during atmospheric nuclear tests:
 - 29 DTC (95%CI: 8-97), i.e., 2.3% (95%CI: 0.6-7.7) c the 1524 spontaneous DTC expected from 1971 to 2070 in this population.
 - Among these 29 DTC in excess,
 - 17 DTC (95%CI: 5-58) before 2022, i.e., 2.1% (95%CI: 0.6% to 6.9%) of the 1141 "natural" DTC predicted for this period.
 - 27 (95%CI: 7-88) were expected to have occurred in women and 2 (95%CI: 1-7) in men.
 - Similar calculations with RadRat NCI software (23) using Japanese life table and thyroid cancer incidence rates in 2010 led to a lifetime attributable risk of 15 DTC (95%CI: 3-34).

