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Co-occurrence of habit-forming risk behaviors and their socio-demographic, health status and lifestyle determinants: a population-based cross-sectional study

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Abstract

Background Although habit-forming risk behaviors frequently co-occur, determinants of concurrent risk behaviors have rarely been investigated. The aim of the present study was to investigate socio-demographic, health status, and lifestyle determinants of single versus concurrent risk behaviors in general-population adults.

Methods We analyzed data from 32,622 participants (74.5% female; mean age = 57.9 ± 14.2 years) of the NutriNet-Santé cohort who completed the Alcohol Use Disorders Identification Test, the 12-item Cigarette Dependence Scale, the modified Yale Food Addiction Scale 2.0, and the Internet Addiction Test in 2021–2022. Using established cutoffs, participants were first split into 2 groups (presence versus absence) for each risk variable (alcohol use disorders, nicotine dependence, food addiction, Internet addiction) and were then divided into 3 groups (no risk behavior, 1 risk behavior (reference), and ≥ 2 risk behaviors). The association between socio-demographic, health status, and lifestyle exposures and individual/concurrent risk behaviors were investigated with polytomous logistic regression.

Results Younger age (Odds Ratio (OR) = 2.04; 95% Confidence Interval (CI: 1.62–2.56), current financial difficulties (OR = 1.29; CI: 1.08–1.54), self-perceived poor health (OR = 1.70; CI: 1.32–2.20), overall poor dietary quality (OR = 2.88; CI: 2.06–4.02), being underweight (OR = 1.46; CI: 1.05–2.04), having obesity (OR = 1.62; CI: 1.31–1.99), lack of affection during childhood (OR = 1.41; CI: 1.18–1.69), and a lifetime prevalence or medication use for a mental disorder (OR = 1.46; CI: 1.24–1.73) were positively associated with having ≥ 2 versus 1 risk behavior (all $p < 0.05$). The comparison of none versus 1 risk behavior revealed the same determinants in addition to having a higher education, being physically active at work, and being overweight.

Conclusions We investigated determinants of concurrent habit-forming risk behaviors among adults in a large, population-based study. The findings could serve as impetus for future research in this domain and ultimately help guide addiction prevention efforts.

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Keywords Addictive behaviors, Alcohol, Food addiction, Internet addiction, Substance use disorders, General population

Text box 1. Contributions to the literature

- Concurrent mental health disorders are generally associated with increased severity and poorer prognosis.
- Younger age, financial difficulties, poor self-perceived health and diet quality, not being of normal weight, lack of affection during childhood, and a lifetime prevalence of other mental disorders were determinants of concurrent versus individual habit-forming/addictive behaviors in this large population-based study.
- This study helps to identify vulnerable population subgroups to be targeted by addiction prevention programs.

Introduction

Substance use disorders (SUD) are underscored by a loss of control as well as seeking or compulsive use of substances despite negative aftereffects [1]. Among the ten substances addressed in the Diagnostic and Statistical Manual of Mental Disorders – 5th edition (DSM-5), alcohol and tobacco are the most widely used substances around the world, with serious health consequences [2, 3]. The most recent World Health Organization estimates indicate that 43% of the global population aged ≥ 15 years are current drinkers [4] and 22.3% use tobacco [3]. Among French adults, current data show that 10% reported to be daily drinkers [5] and 30.4% reported to be smokers [6]. As regards alcohol use disorders (AUD), the average lifetime prevalence was estimated at 8.6% according to the World Mental Health Survey including studies conducted between 2001 and 2015 in 27 countries around the world [7]. In turn, the concept of food addiction (FA) was first introduced in the 1950s [8] yet remains controversial to this day [9]. Research interest in FA has spiked in recent years, given the popularity of industrially processed, highly palatable, and intensely marketed foods [10, 11]. A meta-analysis including 272 studies from around the world estimated a pooled prevalence of FA at 14% in non-clinical samples [12]. The DSM-5 also defines non-substance-related disorders [1], which are increasingly attracting research attention. Internet gaming disorder – while not yet recognized as an addiction – is mentioned in the DSM-5 as meriting further research [1]. According to a meta-analysis published in 2022 and including 341 studies, the global prevalence of Internet addiction (IA) in all ages was estimated at 14.2% [13]. It is also important to note the prevalent comorbidity, i.e., the presence or accumulation of ≥ 2 distinct health conditions in the same individual [14], of these habit-forming risk behaviors. Indeed, numerous studies have been conducted on the co-occurrence of AUD–nicotine dependence (ND) [15]. Comorbidity is generally associated with increased symptom severity of each disorder and with a poorer prognosis [14].

Considering the heavy burden of these habit-forming risk behaviors, it is crucial to explore associated socio-demographic, health status, and lifestyle determinants in order to inform addiction prevention efforts. Thus far, epidemiological studies have suggested determinants of individual risk behavior. The most prominent determinants include: younger age [16–19], male sex [13, 20, 21], adverse childhood experiences [20], low socio-economic status [17, 20], low education [18, 20], experiencing a stressful life event [20], being unmarried [17], low physical activity [22, 23], not being of normal weight [19, 24, 25], having a low healthy lifestyle score (with 9 dimensions including nutrition and exercise) [26], and having other mental health conditions [23, 24, 27, 28]. However, limitations of the existing studies include the use of specific homogeneous samples, such as young adults, medical students, and smokers [20–22, 24], and studying each risk behavior separately. Even though studies suggest a high correlation among these behaviors [15, 29–34], there is a paucity of research on concurrent habit-forming risk behaviors and associated factors. Therefore, the aim of the present study was to describe socio-demographic, health status, and lifestyle determinants of individual and concurrent habit-forming risk behaviors in a sample recruited from the general population. A greater focus was placed on identifying determinants of the number rather than the type of habit-forming risk behaviors. We use the term "habit-forming risk behavior" rather than "addictive behavior" because the assessment (described below) was based on self-reported information, not on clinical diagnoses of addiction, and also because some of the behaviors are not yet officially recognized as addictive. Over the last few years, habit formation theory has gained in prominence for explaining addiction [35] which underscores difficulty in overcoming habitual responses [36]. We hypothesized that individuals with known risk factors would be more likely to exhibit concurrent rather than a single risk behavior.

Methods

The NutriNet-Santé cohort

NutriNet-Santé is an ongoing prospective cohort launched in France in 2009. The main objectives are to investigate the multifaceted relationship between nutrition and health, as well as the determinants of dietary behaviors and physical activity. Its design and protocol were detailed elsewhere [37]. Briefly, recurrent multimedia calls target adults aged 18 years and older who

are able to follow an Internet-based study protocol in French (https://etude-nutrinet-sante.fr/). NutriNet-Santé was approved by the Institutional Review Board of the French Institute for Health and Medical Research and by the National Commission on Informatics and Liberty. The cohort is registered at: https://clinicaltrials.gov/ct2/show/NCT03335644. Eligible volunteers provide informed consent prior to enrollment.

At inclusion and every year thereafter, participants are asked to complete a set of questionnaires regarding socio-demographic and lifestyle characteristics, anthropometrics, physical activity, diet (every six months), and health status. Additional nutrition- or health-related questionnaires (described below) are sent to participants on a regular basis as part of the follow-up.

Data collection

Main outcomes: habit-forming risk behavior assessment

In NutriNet-Santé, risk behavior assessment took place between July 2021 and January 2022 using a comprehensive questionnaire. Of the 151,397 participants who received it, a total of 33,985 returned the questionnaire within 6 months and were thus eligible for this analysis. The present study deals with four types of risk behaviors: AUD, ND, FA, and IA. Each type of risk behavior was first dichotomized (presence or absence, as detailed below) and then participants were split into three groups: no risk behavior, 1 risk behavior (any type), and ≥2 risk behaviors.

Alcohol Use Disorders Identification Test (AUDIT)

The AUDIT was developed by a six-country World Health Organization collaborative project as a screening instrument for harmful alcohol consumption and alcohol dependence [38]. This questionnaire contains 10 items: 3 items for alcohol consumption (frequency, amount, and heavy use); 5 items for drinking behavior over the past year, which are scored on a 5-point Likert scale ranging from 0 to 4 points; and 2 items for alcohol-related problems (i.e., injuries due to drinking, concern by a friend or doctor for one's drinking) scored with 0, 2, or 4 points each. The total score is thus 40 points and a score≥8 is considered an indicator of hazardous and harmful alcohol use [38]. Compared with a DSM-5- defined moderate to severe AUD, an 8-point cut-off presented sensitivity and specificity of 73% and 90%, respectively, in males, 76% and 97%, respectively, in females [39]. The French version of AUDIT demonstrated high internal consistency (Cronbach's alpha=0.87) in a sample of 1,207 adults (mean age=43.2±17.2 years; 51.6% females) [40].

12-Item Cigarette Dependence Scale (CDS-12)

The CDS-12 was originally developed and validated in the French language on the basis of qualitative and quantitative data on cigarette dependence in an international Internet-based sample of 3,009 smokers (age range 18–70 years) [41]. This 12-item questionnaire covers the key aspects of the definitions of dependence from the DSM-IV and the International Classification of Diseases 10th Revision, namely compulsion, withdrawal symptoms, loss of control, time allocation, neglect of other activities, and persistence despite harm [41]. Each item is scored on a 5-point Likert scale ranging from 1 to 5 points with a maximum score of 60 points [41]. The CDS-12 showed a high test-retest reliability (r=0.84), and a high internal consistency (Cronbach's alpha=0.90) in the original sample [41]. The cut-off of 43 points showed the highest sensitivity (64%) and specificity (68%) when compared against ND assessed by the Mini International Neuropsychiatric Interview [42]. As the CDS-12 has been validated against ND as defined in the DSM-IV, this terminology was retained in the present study, even when citing studies using other terms (e.g., tobacco use disorders).

Modified Yale Food Addiction Scale 2.0 (mYFAS 2.0)

The mYFAS 2.0 was derived from the YFAS 2.0 including 35 items of the DSM-5 criteria for substance-related and addictive disorders applied to highly palatable food [43]. The mYFAS 2.0 consists of 13 items: one item for each of the 11 DSM-5 diagnostic criteria and 2 items for impairment and distress experienced over the past year [43]. Each item was first scored on an 8-point Likert scale ranging from 0 (never) to 7 (every day). Then, item-specific cut-off values [43] were applied to dichotomize each item (presence versus absence of risk). Participants with ≥1 positive response (i.e., presence) on impairment or distress and ≥2 positive responses on any of the 11 items assessing DSM-5 diagnostic criteria were considered as having a FA phenotype [43]. The French version of the mYFAS 2.0 displayed significant correlations with the YFAS 2.0 (r=0.83), Body Mass Index (BMI) (r=0.17), binge eating (r=0.42), cognitive restraint (r=0.24), uncontrolled eating (r=0.30), and emotional eating (r=0.31) in a non-clinical sample (n=250; mean age=28.4±11.3 years; 80.0% females) [43].

Internet Addiction Test (IAT)

The IAT is a validated and widely used questionnaire regarding problematic Internet use [44]. It contains 20 items assessing symptoms of IA: user's preoccupation with the Internet, ability to control use, extent of hiding or lying about one's Internet use, and continued Internet use despite negative consequences [45]. Each item is scored on a 5-point Likert scale ranging from 1 (never) to 5 (always) points with a maximum score of 100 points [45]. A score of ≥50 points identifies problematic Internet use [45]. The French version of IAT showed good

psychometric properties in a sample of 246 participants (mean age = 24.1 ± 9.0 years, range 18–54 years; 67.0% females): Cronbach's alpha = 0.93; significant correlations were reported with daily duration of Internet use (r = 0.53) and age (r = -0.23) [45].

Main exposures: socio-demographic, health status, and lifestyle characteristics

Established determinants of individual habit-forming risk behavior were selected as exposure variables in the present study. A validated socio-demographic questionnaire was used to collect self-reported data on age which was modeled as categories (18–39; 40–59; ≥60 years), sex (female; male), and educational level (less than high school; high school diploma or equivalent; some college, undergraduate degree; graduate degree) [46]. The online version of this questionnaire was validated in comparison with a standard paper-and-pencil questionnaire [46]. As regards height and weight, a validated self-reported anthropometric questionnaire was used [47], which allowed us to calculate BMI (kg/m^2). Participants were split into four categories according to their anthropometric status (underweight: <18.5, normal weight: 18.5–24.9, overweight: 25.0–29.9, and obese: ≥30.0 kg/m^2). The validity of the self-reported height and weight online was established in comparison with clinical measurements and with a paper-and-pencil version of the tool [47]. As the socio-demographic and anthropometric questionnaires are administered at baseline and annually thereafter, data recorded on the date closest to the assessment date of the risk behaviors were used for the present study. Data on self-reported lifetime prevalence and/or medication use for other mental health conditions (yes; no) were collected by an annual health status questionnaire.

Information on current household financial situation (comfortable or good; barely making it; in debt) [48], self-perceived health status (very good or good; acceptable; poor or very poor) [48], self-perceived dietary quality (excellent or very good; good or acceptable; poor) [49], smoking status (never smoker; former smoker; current smoker) [46], e-cigarette use (yes; no) [48], current alcohol use (0 glass/week; <2 glasses/week; ≤2–6 glasses/week; ≥7 glasses/week), self-perceived lack of affection during childhood (yes; no), type of profession (mostly active; mostly sedentary; retired or other), and prior divorce (yes; no) was collected at the same time as the habit-forming risk behaviors assessment. It should be noted that smoking (regular and e-cigarettes) and drinking were retained as potential determinants since they do not by themselves refer to problematic substance use. The latter is defined not only by the frequency or amount of consumption, but also by other important criteria, such as tolerance, withdrawal, compulsion, loss of control, chronicity of the behavior, and deleterious consequences in daily life [1].

Statistical analyses

Participants with incomplete data on risk behaviors were excluded from this analysis. Likewise, participants lacking data on BMI in a 5-year window around the risk behavior assessment and those lacking data on educational level were also excluded. The remaining covariables did not have any missing values.

Descriptive characteristics are presented in the full sample and according to sex, given evidence for associations between sex and each habit-forming risk behavior [13, 20, 21]. The data reflect number (percent) from chi-squared tests (categorical variables) and mean (±SD) from Student's t-test (continuous variables). For the main analyses, the associations between socio-demographic, health status, and lifestyle characteristics (exposure variables) and habit-forming risk behavior status (outcome variable categorized as: no risk behavior, 1 risk behavior = reference, and ≥2 risk behaviors) were assessed using polytomous logistic regression. In a sensitivity analysis, the same associations were assessed using no risk behavior as reference. Since we were interested in investigating sex as a determinant of the number of risk behaviors, the main analyses were conducted in the full sample. The following exposure variables were modelled in the main analysis and were mutually adjusted for: sex, age category, education, type of profession, prior divorce, current household financial situation, self-perceived dietary quality, BMI category, tobacco smoking status, current e-cigarette use, current alcohol use, lack of affection during childhood, and self-reported lifetime prevalence or medication use for a mental health condition. All tests were two-sided and $p < 0.05$ was considered as evidence for statistical significance. SAS version 9.4 (SAS Institute, Inc., Cary NC, USA) was used for all statistical analyses.

Results

Description of study sample

In total, 33,273 participants had complete data on habit-forming risk behaviors. After excluding those lacking data on BMI or educational level, the final sample for the analysis included 32,622 adults [participant flowchart presented in Fig. 1] (74.5% female; mean age = 57.9 ± 14.2 years). Participants included in the analysis were older, more likely to be male, retired, former smokers, to have good self-perceived health status and good dietary quality, less likely to have AUD, IA, or to experience financial difficulties compared to those excluded from the analysis (data not tabulated). The grouping of participants according to habit-forming risk behavior status was as follows:

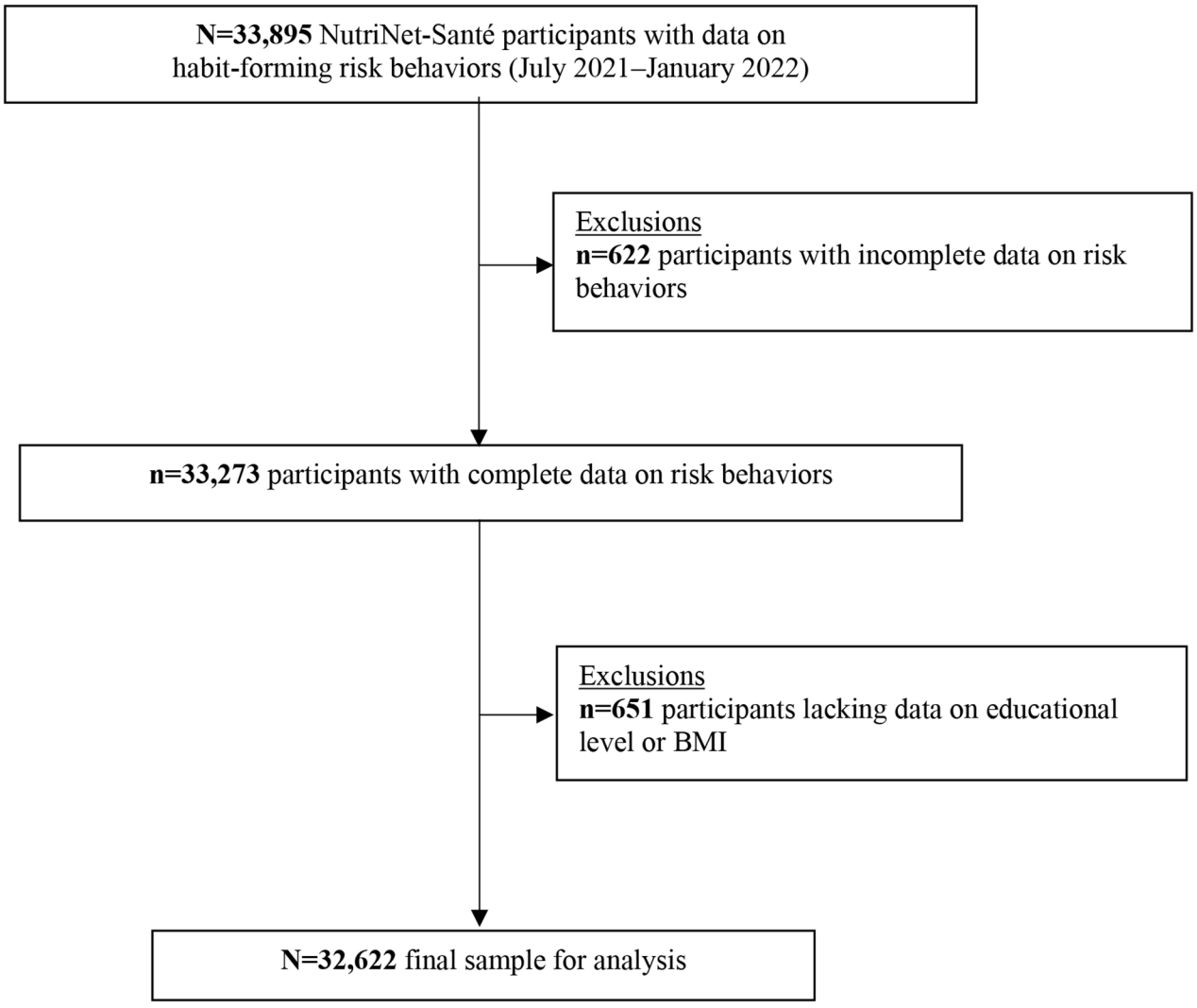

Fig. 1 Participant selection flowchart

"no risk behavior" $n=27,036$ (82.9%); "1 risk behavior, any type" $n=4,702$ (14.4%); "≥2 risk behaviors" $n=884$ (2.7%).

Table 1 presents the participants' socio-demographic and lifestyle characteristics in the full sample and according to sex. Female participants were more likely to be younger, underweight or normal weight, to experience current financial difficulties, to have an undergraduate degree, self-perceived poor dietary quality, were less likely to be retired, former smokers, and to consume alcohol (in terms of frequency and/or quantity) compared to male participants (all $p<0.0001$).

Table 2 presents participants' psychological and mental health characteristics in the full sample and according to sex. Compared to males, females were more likely to report a lack of affection during childhood, to have ND, FA, other mental health conditions, and were less likely to have AUD (all $p<0.0001$).

The frequency distributions of the participants having a combination of two risk behaviors ($n=788$), and those having a combination of three risk behaviors ($n=91$) are presented in Supplementary tables S1 and S2, respectively.

Associations between socio-demographic, health status, and lifestyle characteristics and habit-forming risk behavior status

Table 3 shows the main results obtained from adjusted polytomous logistic regression in the full sample. Younger age, current financial difficulties, self-perceived poor health and poor dietary quality, being underweight, having obesity, current tobacco use, heavy alcohol use, lack of affection during childhood, and a lifetime prevalence or medication use for a mental health condition were positively associated with having≥2 risk behaviors compared to having 1 risk behavior (reference)

Table 1 Descriptive characteristics of the participants in the full sample and according to sex (*N* = 32,622; NutriNet-Santé cohort; 2021–2022; France)

	Full sample ***N*** **= 32,622**		**Males** ***n*** **= 8,307**		**Females** ***n*** **= 24,315**		***p*-value**[a]
Age, years, mean (SD)	57.9	(14.2)	62.6	(13.6)	56.3	(14.0)	< 0.001
Age category							
18–39 years	4,305	(13.2)	618	(7.4)	3,687	(15.2)	< 0.001
40–59 years	11,560	(35.4)	2,360	(28.4)	9,200	(37.8)	
≥ 60 years	16,757	(51.4)	5,329	(64.2)	11,428	(47.0)	
Educational level							
Less than high school	4,024	(12.3)	1,221	(14.7)	2,803	(11.5)	< 0.001
High school diploma or equivalent	5,033	(15.4)	1,347	(16.2)	3,686	(15.2)	
Some college, undergraduate	10,197	(31.3)	2,122	(25.5)	8,075	(33.2)	
Graduate degree	13,368	(41.0)	3,617	(43.5)	9,751	(40.1)	
Type of professional activity							
Mostly sedentary	12,874	(39.5)	2,702	(32.5)	10,172	(41.8)	< 0.001
Mostly active	4,520	(13.9)	865	(10.4)	3,655	(15.0)	
Retired	14,574	(44.7)	4,685	(56.4)	9,889	(40.7)	
Other[b]	654	(2.0)	55	(0.7)	599	(2.5)	
Prior divorce							
No	24,704	(75.7)	6,343	(76.4)	18,361	(75.5)	0.12
Yes	7,918	(24.3)	1,964	(23.6)	5,954	(24.5)	
Current household financial situation							
Comfortable, good	27,612	(84.6)	7,243	(87.2)	20,369	(83.8)	< 0.001
Barely making it	4,862	(14.9)	1,031	(12.4)	3,831	(15.8)	
In debt	148	(0.5)	33	(0.4)	115	(0.5)	
Self-perceived health status							
Very good, good	22,094	(67.7)	5,614	(67.6)	16,480	(67.8)	0.81
Acceptable	8,925	(27.4)	2,274	(27.4)	6,651	(27.4)	
Poor or very poor	1,603	(4.9)	419	(5.0)	1,184	(4.9)	
Self-perceived dietary quality							
Excellent, very good	13,013	(39.9)	3,608	(43.4)	9,405	(38.7)	< 0.001
Good, acceptable	19,171	(58.8)	4,615	(55.6)	14,556	(59.9)	
Poor	438	(1.3)	84	(1.0)	354	(1.5)	
Body mass index (BMI; kg/m^2), mean (SD)	24.3	(4.7)	25.1	(3.9)	24.0	(4.9)	< 0.001
BMI category							
Underweight (< 18.5)	1,614	(5.0)	101	(1.2)	1,513	(6.2)	< 0.001
Normal weight (18.5–24.9)	19,289	(59.1)	4,482	(54.0)	14,807	(60.9)	
Overweight (25.0–29.9)	8,197	(25.1)	2,864	(34.5)	5,333	(21.9)	
Obesity (≥ 30.0)	3,522	(10.8)	860	(10.4)	2,662	(11.0)	
Tobacco smoking status							
Never smoker	21,243	(65.1)	4,847	(58.4)	16,396	(67.4)	< 0.001
Former smoker	8,841	(27.1)	2,911	(35.0)	5,930	(24.4)	
Current smoker	2,538	(7.8)	549	(6.6)	1,989	(8.2)	
Current e-cigarette use							
No	31,831	(97.6)	8,130	(97.9)	23,701	(97.5)	0.09
Yes, without nicotine	128	(0.4)	25	(0.3)	103	(0.4)	
Yes, with nicotine	663	(2.0)	152	(1.8)	511	(2.1)	
Alcohol use, # glasses/week[c]							
0	4,735	(14.5)	769	(9.3)	3,966	(16.3)	< 0.001
< 2	15,198	(46.6)	3,035	(36.5)	12,163	(50.0)	

Table 1 (continued)

	Full sample *N* = 32,622		Males *n* = 8,307		Females *n* = 24,315		*p*-value[a]
2–6	11,275	(34.6)	3,747	(45.1)	7,528	(31.0)	
≥ 7	1,414	(4.3)	756	(9.1)	658	(2.7)	

Values refer to number (%) except when noted otherwise

[a] Values are obtained from Chi-2 or Student t-tests, as appropriate

[b] Without professional activity (homemaker, sick leave, unemployment, parental leave, disability) or not specified

[c] 1 glass = 10 g of ethanol

Table 2 Psychological and mental health characteristics of the participants in the full sample and according to sex (*N* = 32,622; NutriNet-Santé cohort; 2021–2022; France)

	Full sample *N* = 32,622		Males *n* = 8,307		Females *n* = 24,315		*p*-value[a]
Lack of affection during childhood							
No	28,409	(87.1)	7,627	(91.8)	20,782	(85.5)	< 0.001
Yes	4,213	(12.9)	680	(8.2)	3,533	(14.5)	
Self-reported lifetime prevalence or medication use for a mental health condition[b]							
No	18,359	(56.3)	5,738	(69.1)	12,621	(51.9)	< 0.001
Yes	14,263	(43.7)	2,569	(30.9)	11,694	(48.1)	
Alcohol use disorders[c]							
No	30,289	(92.8)	7,349	(88.5)	22,940	(94.3)	< 0.001
Yes	2,333	(7.2)	958	(11.5)	1,375	(5.7)	
Nicotine dependence[c]							
No	32,043	(98.2)	8,211	(98.8)	23,832	(98.0)	< 0.001
Yes	579	(1.8)	96	(1.2)	483	(2.0)	
Food addiction[c]							
No	30,958	(94.9)	8,155	(98.2)	22,803	(93.8)	< 0.001
Yes	1,664	(5.1)	152	(1.8)	1,512	(6.2)	
Internet addiction[c]							
No	30,627	(93.9)	7,806	(94.0)	22,821	(93.9)	0.71
Yes	1,995	(6.1)	501	(6.0)	1,494	(6.1)	
Number of habit-forming risk behaviors[c]							
0	27,036	(82.9)	6,833	(82.3)	20,203	(83.1)	0.08
1	4,702	(14.4)	1,266	(15.2)	3,436	(14.1)	
2	788	(2.4)	185	(2.2)	603	(2.5)	
3	91	(0.3)	21	(0.3)	70	(0.3)	
4	5	(0.0)	2	(0.0)	3	(0.0)	

Values refer to number (%)

[a] Values are obtained from Chi-2 tests

[b] Mental health conditions include memory impairment, Alzheimer's disease, anorexia nervosa, anxiety disorders, bipolar disorder, depression, and insomnia

[c] Habit-forming risk behaviors include alcohol use disorders, nicotine dependence, food addiction, and Internet addiction, which were assessed by the Alcohol Use Disorders Identification Test (≥ 8 points), the 12-item Cigarette Dependence Scale (≥ 43 points), the modified Yale Food Addiction Scale 2.0, and the Internet Addiction Test (≥ 50 points), respectively. Scoring for each scale was based on established criteria

(all $p < 0.05$). The significant ORs ranged from 1.29 (CI: 1.08–1.54) for current financial difficulties to 2.88 (CI: 2.06–4.02) for self-perceived poor dietary quality. Non-significant results were observed for sex (OR = 0.89; CI: 0.73–1.07), high educational attainment (OR = 0.99; CI: 0.76–1.28), not being physically active at work (OR = 1.10; CI 0.88–1.37), a prior divorce (OR = 0.87; CI: 0.72–1.05), and current e-cigarette use (OR = 1.09; CI: 0.82–1.44).

All significant determinants of having ≥ 2 risk behaviors, plus having a higher educational attainment, being physically active at work, being overweight, and current e-cigarette use were inversely associated with having none versus 1 risk behavior (reference). The significant ORs ranged from 0.05 (CI: 0.04–0.06) for heavy alcohol use to 0.85 (CI: 0.78–0.94) for current financial difficulties (all $p < 0.05$). Results for sex (OR = 0.92; CI: 0.85–1.00) and a prior divorce (OR = 0.93; CI: 0.86–1.01) were not significant.

Results of the sensitivity analysis, modelling no risk behavior as reference, are presented in Supplementary

Table 3 Associations of socio-demographic, health status, and lifestyle characteristics with number of habit-forming risk behaviors[a] (*N* = 32,622, reference = 1 risk behavior; NutriNet-Santé cohort; 2021–2022; France)

	No risk behavior *n* = 27,036			≥ 2 risk behaviors *n* = 884			Overall *p*-value[b]
	OR[b]	(95% CI)[b]	*p*-value[b]	OR[b]	(95% CI)[b]	*p*-value[b]	
Sex							0.125
Female	1			1			
Male	0.92	(0.85–1.00)	0.06	0.89	(0.73–1.07)	0.21	
Age category							< 0.001
18–39 years	0.20	(0.18–0.22)	< 0.001	2.04	(1.62–2.56)	< 0.001	
40–59 years	0.46	(0.42–0.50)	< 0.001	1.32	(1.09–1.60)	0.004	
≥ 60 years	1			1			
Educational level							< 0.001
Less than high school	1			1			
High school diploma or equivalent	0.90	(0.78–1.04)	0.15	0.99	(0.73–1.34)	0.94	
Some college, undergraduate, graduate degree	0.77	(0.68–0.86)	< 0.001	0.99	(0.76–1.28)	0.91	
Type of professional activity							< 0.001
Mostly sedentary, retired, other[c]	0.83	(0.75–0.91)	< 0.001	1.10	(0.88–1.37)	0.39	
Mostly active	1			1			
Prior divorce							0.148
No	1			1			
Yes	0.93	(0.86–1.01)	0.10	0.87	(0.72–1.05)	0.14	
Current household financial situation							< 0.001
Comfortable, good	1			1			
Barely making it, in debt	0.85	(0.78 − 0.94)	< 0.001	1.29	(1.08–1.54)	0.005	
Self-perceived health status							< 0.001
Very good, good	1			1			
Acceptable	0.76	(0.70–0.82)	< 0.001	1.30	(1.09–1.55)	0.003	
Poor or very poor	0.53	(0.46–0.61)	< 0.001	1.70	(1.32–2.20)	< 0.001	
Self-perceived dietary quality							< 0.001
Excellent, very good	1			1			
Good, acceptable	0.63	(0.58–0.68)	< 0.001	1.39	(1.14–1.69)	< 0.001	
Poor	0.20	(0.16–0.26)	< 0.001	2.88	(2.06–4.02)	< 0.001	
BMI (kg/m^2) category							< 0.001
Underweight (< 18.5)	0.95	(0.81–1.12)	0.55	1.46	(1.05–2.04)	0.03	
Normal weight (18.5–24.9)	1			1			
Overweight (25.0–29.9)	0.76	(0.70–0.83)	< 0.001	1.18	(0.98–1.43)	0.08	
Obesity (≥ 30.0)	0.54	(0.48–0.60)	< 0.001	1.62	(1.31–1.99)	< 0.001	
Tobacco smoking status							< 0.001
Never smoker	1			1			
Former smoker	0.74	(0.68–0.80)	< 0.001	0.96	(0.80–1.16)	0.69	
Current smoker	0.33	(0.29–0.36)	< 0.001	1.97	(1.62–2.39)	< 0.001	
Current e-cigarette use							< 0.001
No	1			1			
Yes	0.71	(0.59–0.85)	< 0.001	1.09	(0.82–1.44)	0.56	
Alcohol use, # glasses/week[d]							< 0.001
0	1			1			
< 2	1.07	(0.96–1.20)	0.19	1.05	(0.80–1.37)	0.74	
2–6	0.63	(0.56–0.70)	< 0.001	1.86	(1.43–2.43)	< 0.001	
≥ 7	0.05	(0.04–0.06)	< 0.001	2.82	(2.10–3.80)	< 0.001	
Lack of affection during childhood							< 0.001
No	1			1			
Yes	0.58	(0.53–0.63)	< 0.001	1.41	(1.18–1.69)	< 0.001	
Self-reported lifetime prevalence or medication use for a mental health condition[e]							

Table 3 (continued)

	No risk behavior *n* = 27,036			≥ 2 risk behaviors *n* = 884			Overall *p*-value[b]
	OR[b]	(95% CI)[b]	*p*-value[b]	OR[b]	(95% CI)[b]	*p*-value[b]	
No	1			1			< 0.001
Yes	0.63	(0.58–0.67)	< 0.001	1.46	(1.24–1.73)	< 0.001	

BMI: Body Mass Index; CI: Confidence Interval; OR: Odds Ratio

[a] Habit-forming risk behaviors include alcohol use disorders, nicotine dependence, food addiction, and Internet addiction, which were assessed by the Alcohol Use Disorders Identification Test (≥ 8 points), the 12-item Cigarette Dependence Scale (≥ 43 points), the modified Yale Food Addiction Scale 2.0, and the Internet Addiction Test (≥ 50 points), respectively

[b] Values are obtained from a polytomous logistic regression model (reference = 1 risk behavior; *n* = 4,702). Variables are mutually adjusted

[c] Other = Without professional activity (homemaker, sick leave, unemployment, parental leave, disability) or not specified

[d] 1 glass = 10 g of ethanol

[e] Mental health conditions include memory impairment, Alzheimer's disease, anorexia nervosa, anxiety disorders, bipolar disorder, depression, and insomnia

table S3. We observed significant results for the same determinants as those seen in the main analysis and linear trends with higher odds as the number of risk behaviors increased.

Discussion

This large population-based study revealed that a number of socio-demographic, health status, and lifestyle characteristics were associated with having none, a single or concurrent (≥ 2) habit-forming risk behaviors, which supported our main hypothesis. When comparing ≥ 2 versus 1 habit-forming risk behavior, significantly increased ORs were observed for younger age, current household financial difficulties, self-perceived poor health and poor dietary quality, being underweight, having obesity, current tobacco use, current heavy alcohol use, lack of affection during childhood, and a lifetime prevalence or medication use for a mental health condition. In turn, high educational level, not being physically active at work, and current e-cigarette use were significantly associated with having a single (but not concurrent) risk behavior versus having no risk behaviors. Interestingly, sex and prior divorce did not emerge as significant determinants of either single or concurrent risk behaviors.

Consistent with our findings, previous studies have linked socio-demographic, health status, and lifestyle characteristics with individual risk behaviors. Specifically, younger age was shown to be a determinant of SUD [50], FA [18, 19], and IA [16, 17], respectively; adverse childhood experiences were shown to be a determinant of SUD [20]; poor dietary quality or disordered eating have been associated with alcohol use [51], FA [52, 53], and IA [54, 55], respectively; not being of normal weight has been associated with FA [19, 24, 56] and IA [25], respectively; smoking has been associated with AUD [29], FA [31, 32], and IA [33], respectively; alcohol use has been associated with ND [29] and IA [34]; finally, presence of other mental health conditions has been associated with SUD [50], FA [23, 24, 27, 56], and IA [28], respectively. The clustering of determinants has been evoked by descriptive studies showing a positive association of occupational sitting time with education and income [57]. In the addiction literature, educational level was positively associated with SUD [20] and inversely associated with IA [13]. People with a high educational level might be more likely to consume alcohol than those with a lower educational level [58]; moreover, having a higher educational attainment has been positively associated with heavy episodic drinking in young adults [58]. Such findings could partially explain our results. Next, low physical activity and sedentariness have been positively associated with hazardous drinking [59]. Prior studies have also linked low physical activity with IA and FA, respectively [22, 23]. Future studies are needed to shed more light on the role of sedentariness and physical activity in concurrent habit-forming risk behaviors.

Previous research has suggested the co-occurrence of each pair of AUD, ND, FA, and IA [29, 34, 54]. For example, a review reported the co-existence of SUD and IA [34]; a cross-sectional study including 36,309 adults revealed a significant association between AUD and ND [29]. In a systematic review and meta-analysis including cross-sectional and prospective studies, eating underscored by a loss of control and binge eating disorders, which are highly correlated with FA [56, 60, 61], were reported to be associated with IA [54]. A cross-sectional study also suggested significant associations between problematic Internet use and eating disorders in both males and females [62]. The preoccupation with the Internet, in particular, was a strong predictor of eating disorders in that study [62]. In terms of the underlying mechanisms, SUD and other habit-forming risk behaviors might share the same neurobiological basis (e.g., dopamine reward system), genetic overlap, and psychosocial antecedents (e.g., impulsivity) [63]. Studies have also reported neurobiological and psychological parallels between ND or SUD and FA, such as activation of the dopaminergic reward pathways, opioid and cannabinoid systems, gut-brain axis mechanisms, chronic stress during childhood affecting the nervous, endocrine, and

immune systems, and emotional development [32, 50, 56, 64]. Moreover, a literature review suggested that co-occurrence of SUD and IA could be explained by shared psychosocial factors, such as low self-esteem, poor family functioning, low life satisfaction, and personality more likely to engage in a behavior perceived as rewarding [34]. In turn, postulated shared neurobiological mechanisms between alcohol and tobacco use include cross-reinforcement and cross-tolerance [15]. The former refers to each substance's role in increasing consumption of the other substance by impacting the mesolimbic dopamine pathway and the latter indicates that nicotine reduces the sedative and intoxication effects of alcohol, leading to increased alcohol use [15]. Given that comorbidity has been linked to increased symptom severity and poorer prognosis of each individual disorder [14], our results, along with future studies in this domain, could help identify the most at-risk populations to be targeted by prevention efforts aiming to improve lifestyle behaviors and reduce the likelihood of habits leading to addiction.

In the present study, we were interested in investigating alcohol consumption, tobacco smoking status, and e-cigarette use as determinants of the number rather than the type of habit-forming risk behaviors. This decision was driven by the fact that problematic substance use takes into account not only the frequency or amount of consumption, but also tolerance, withdrawal, compulsion, loss of control, chronicity of the behavior, and deleterious consequences in daily life [1]. A study based on general-population surveys from 9 European countries reported a weak correlation between frequency of alcohol use and the AUDIT total score [65]. In addition, the majority of participants with excessive drinking in repeated cross-sectional studies of U.S. representative samples [66] did not meet the alcohol dependence criteria. Indeed, in the present study, the Spearman's correlation coefficient between alcohol use (glasses/week) and AUDIT score was modest ($r=0.35$; $p<0.001$). In prior studies, binge drinking and alcohol dependence were shown to have distinct determinants; the prevalence of alcohol dependence was estimated at 10.5% among binge drinkers and 1.3% among non-binge drinkers [66]. As regards tobacco use, a longitudinal study with a representative U.S. sample reported that nearly half of smokers did not have ND as defined by the DSM-IV [67]. Indeed, individual differences in nicotine reinforcement and withdrawal according to sex, anthropometric characteristics, and mental health status have been evoked [68], which could help explain differences in ND among smokers. In addition, addiction to a substance is strongly linked to the age at initiation [69]. Finally, e-cigarettes might hold a reduced addictive potential than conventional cigarettes [70]. In our study, current e-cigarette use did not emerge as a significant determinant of concurrent risk behaviors, possibly owing to the relatively small number of participants reporting this behavior.

Limitations of the present study must be noted. First, even though the risk behaviors were estimated with instruments validated against or based on DSM diagnostic criteria, which argues for the utility of self-reported measures in epidemiological research [40, 42, 43, 45], they do not correspond to clinical diagnoses of addiction. Moreover, FA and IA are not defined in the DSM-5 [1]. Second, the administration of the exposure questionnaire (July 2021–January 2022) coincided with the COVID-19 pandemic, albeit not at its onset. This unintended aspect might have impacted to some extent the assessed prevalence of the risk behaviors [13, 71]. However, a French national survey has reported stable alcohol and tobacco consumption levels during and outside the lockdown periods [72]. Thus, the results are likely not subject to a strong bias owing to the pandemic which, nonetheless, should be taken into consideration when extrapolating the results. Third, the main results are presented in the full sample because we hypothesized that sex might be a determinant of the number of habit-forming risk behaviors [13, 20, 21]. Fourth, in the present study, the ancillary protocol called for the assessment of ND only among current smokers, thus it was not possible to provide a correlation between smoking status and ND. Fifth, this was a descriptive study using a cross-sectional design; as such, it cannot provide a basis for examining the direction of the associations. Importantly, reverse causation cannot be ruled out. Sixth, caution is needed when generalizing the findings because individuals with SUD are generally less likely to participate in epidemiological research than their SUD-free counterparts [73], which may lead to under-estimation of the studied associations. Also, as seen in epidemiological research in general, the NutriNet-Santé cohort includes a higher proportion of females, individuals with higher educational and socio-economic levels, and a lower smoking prevalence compared to the French general population [74]. This aspect could lead to underestimation of observed associations and should also be taken into account when extrapolating the findings. Future studies could investigate the prevalence of habit-forming risk behaviors in representative samples of the general population and in specific subgroups in order to establish moderators of the associations. Likewise, future mediation analyses could provide evidence for causal pathways.

Despite the limitations, this study has several important strengths. To our knowledge, this is the first large-scale epidemiological study to reveal factors associated with individual versus concurrent habit-forming risk behaviors in a heterogenous sample of adults recruited from the general population. To date, most of the research in this domain has focused on adolescents and

young adults [20–22, 24]. Our study, where the mean age was 57.9 years, could help advance knowledge about determinants of habit-forming risk behaviors in middle age. In addition, we were interested in identifying determinants of multiple concurrent habit-forming risk behaviors, hence we used one risk behavior as reference in the main analysis.

In conclusion, the present study suggests some sociodemographic, health status, and lifestyle determinants of concurrent habit-forming risk behaviors. Future longitudinal studies could elucidate the direction and causality of the observed associations. The present and future findings could help identify targets for addiction prevention efforts at the population level in order to reduce the likelihood of deleterious habits turning into addiction.

Abbreviations

AUD	Alcohol use disorders
AUDIT	Alcohol Use Disorders Identification Test
BMI	Body Mass Index
CI	Confidence interval
CDS-12	12-item Cigarette Dependence Scale
DSM	Diagnostic and Statistical Manual of Mental Disorders
FA	Food addiction
IA	Internet addiction
IAT	Internet Addiction Test
ND	Nicotine dependence
mYFAS	modified Yale Food Addiction Scale
OR	Odds ratio
SUD	Substance use disorders

Supplementary Information

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Supplementary Material 1

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Author contributions

Serge Hercberg, Pilar Galan, and Mathilde Touvier designed and implemented the NutriNet-Santé cohort study; Valentina A. Andreeva and Junko Kose implemented the habit-forming risk behaviors questionnaire and coordinated data collection; Valentina A. Andreeva conceptualized the study, designed the analytic strategy, and provided theoretical and empirical guidance; Junko Kose performed the literature review, statistical analyses and led the writing; all authors assisted with interpretation of the data, critically revised the manuscript for important intellectual content. All authors approved the final version of the manuscript and its submission.

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Data availability

Researchers at public institutions can submit a project collaboration request that includes information about their institution and a brief description of the project to: collaboration@etude-nutrinet-sante.fr. All requests are reviewed by the steering committee of the NutriNet-Santé study. In case of approval, a signed data access agreement will be requested and additional authorizations from the competent administrative authorities may be needed regarding human subjects' data protection. In accordance with existing regulations, no personally identifiable data will be made available.

Declarations

Ethics approval and consent to participate

The NutriNet-Santé cohort study 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 (INSERM # 00000388FWA00005831) and by the National Commission on Informatics and Liberty (CNIL # 908450 and # 909216). NutriNet-Santé is registered at: https://clinicaltrials.gov/ct2/show/NCT03335644. Electronic informed consent was obtained from all volunteers prior to inclusion in the cohort.

Competing interests

The authors declare no competing interests.

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