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RESEARCH

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Changes in household use of disinfectant and cleaning products during the first lockdown period in France

Emilie Pacheco Da Silva^{1*}, Raphaëlle Varraso¹, Laurent Orsi¹, Emmanuel Wiernik², Marcel Goldberg², Christophe Paris³, Léopold K. Fezeu⁴, Céline Ribet², Rachel Nadif¹, Fabrice Carrat^{5,6}, SAPRIS study group, Mathilde Touvier⁴, Marie Zins², Oriane Dumas¹ and Nicole Le Moual¹

Abstract

Background Few studies evaluated the use of Household Disinfectant and Cleaning Products (HDCPs) during the COVID-19 pandemic, but no population-based cohorts used longitudinal data. We studied changes in HDCPs during the first lockdown, based on longitudinal data from the French population-based NutriNet-Santé and CONSTANCES cohorts.

Methods Based on standardized questionnaires on household cleaning tasks in 2018–2019 and around the first lockdown in France (March 17–May 3 2020), we compared the duration of weekly use of HDCPs (< 1 day/week, < 10 min/week; 10–30 min/week; > 30 min/week) and the household cleaning help (yes/no) before and during the lockdown period by Bhapkar and McNemar's tests. Moreover, we assessed self-reported changes in the frequency of HDCPs during the lockdown from before (unchanged/increased).

Results Analyses were carried on 31,105 participants of NutriNet-Santé (48 years, 75% women, 81% ≥ high school diploma) and 49,491 of CONSTANCES (47 years, 51% women, 87% ≥ high school diploma). During the lockdown, compared with 2018–2019, duration of HDCPs use increased (> 30 min; NutriNet-Santé: 44% versus 18%; CONSTANCES: 63% versus 16%) and household help decreased (NutriNet-Santé: 5% versus 40%; CONSTANCES: 3% versus 56%). Regarding the frequency of HDCPs use, 55% of participants of NutriNet-Santé (57% women/49% men) and 83% of CONSTANCES (86% women/81% men) reported an increased use since the beginning of the lockdown, significantly higher among women ($p < 0.0001$).

Conclusions The frequency and duration of weekly use of HDCPs has significantly increased since the pandemic. As the use of HDCPs is associated with health issues, further studies are now needed to evaluate the potential health impacts of these changes.

Keywords Lockdown period, COVID-19, Household disinfectant and cleaning products

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Introduction

In December 2019, a novel coronavirus causing a respiratory infection was identified in Wuhan, China [1, 2]. Very quickly, the virus actively circulated in other regions of China and then spread worldwide, with an exponential number of contaminations. In France, the first imported cases were reported in late January 2020 [3, 4], almost simultaneously with the World Health Organization (WHO) declaring the COVID-19 outbreak as a public health emergency of international concern [2].

The virus is mainly transmitted through droplets, released when an infected person coughs, sneezes, exhales or talks, which can remain in the air or on inanimate surfaces for a long time [5, 6]. At the beginning of the pandemic, due to the lack of treatments and vaccines, the implementation of preventive measures and recommendations was the only option available to fight against the spread of the virus [7]. Among these measures, several governments decided on a strict lockdown of the population. In France, a first lockdown policy was initiated on March 17, 2020 (to May 3) [4], in order to promote social distancing and break the contamination chains [2, 7]. In parallel, several guidelines recommended a regular hand washing with soap or a solution of hydroalcoholic gel and also cleaning and disinfecting surfaces at home to reduce the presence of pathogenic microorganisms and inactivate them [6–10].

Although disinfectants and cleaning products were recommended to limit the spread of the virus, their use in the workplace and at home is at risk for health, especially for chronic respiratory diseases as reported by several studies [11, 12].

Cleaning habits at home since the COVID-19 pandemic were documented by retrospective analyses using National Poison Control Centers data and cross-sectional surveys. Indeed, a significant number of poison control centers in North America [13–16], as well as some countries in Europe [17–21], including in France [22], reported an increased number of calls related to exposures to Household Disinfectant and Cleaning Products (HDCPs) in the first semester of 2020, compared with the number of calls recorded in the same period the previous year(s). In particular, there has been an increase in the number of calls to poison centers related to exposure to surface disinfectants [13–15, 18, 21, 22], including bleach [13, 16, 19, 20], acids [19] and alcohols [20], as well as for exposure to hand sanitizers [13, 16, 18–22]. Among cross-sectional surveys, set up to document lifestyle habits since the pandemic, participants have consistently reported an increased use of HDCPs [23–28]. However, these population-based cross-sectional studies were conducted on a limited number of respondents, ranging from 502 [23] to 3,667 [28]. In addition, no longitudinal

study on large population-based cohorts were conducted to compare the use of HDCPs before and during the first wave of the COVID-19 pandemic, while such data are available in two large French population-based cohorts, NutriNet-Santé and CONSTANCES. Therefore, these two cohorts provided a unique opportunity to study the changes in the use of HDCPs during the COVID-19 pandemic.

We aimed to study the changes in the use of HDCPs during the first lockdown period based on longitudinal data from the NutriNet-Santé and the CONSTANCES studies.

Methods

Populations

The NutriNet-Santé and CONSTANCES studies are two French epidemiological population-based cohorts. In the NutriNet-Santé e-cohort, about 170,000 adult volunteers have been included since 2009, mainly to study the role of various determinants on health status, especially of the diet [29]. In the CONSTANCES cohort, about 220,000 adults, randomly selected among the affiliated people of the French general social security scheme, were included between 2012 and 2021, in order to study social and occupational determinants related to chronic diseases and ageing [30]. During regular follow-up of these cohorts, questionnaires related to household cleaning habits were administered in 2018 and in May–October 2020 in NutriNet-Santé as well as in 2019 in CONSTANCES. In these two cohorts, the SAPRIS survey (“Santé, Perception, pratiques, Relations et Inégalités Sociales en population générale pendant la crise COVID-19”) was introduced in March 2020. This survey was set up to assess the main epidemiological, social and behavioural issues related to the COVID-19 outbreak in France [4, 31]. Questions in SAPRIS regarding cleaning tasks were taken/adapted from previous surveys [32, 33]. The SAPRIS questionnaires were only completed online due to logistical issues related to the lockdown. Therefore, only participants of these two cohorts who usually completed online questionnaires were eligible, i.e., 151,122 participants of NutriNet-Santé and 66,881 web participants of CONSTANCES [4].

Electronic/written informed consent was provided by each individual included in the NutriNet-Santé/CONSTANCES cohort, conducted according to the Declaration of Helsinki guidelines. Both cohorts were 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”.

Our analyses were conducted on 31,105 participants of NutriNet-Santé (Fig. 1a) and 49,491 participants of CONSTANCES (Fig. 1b) who answered to both the 2018–2019

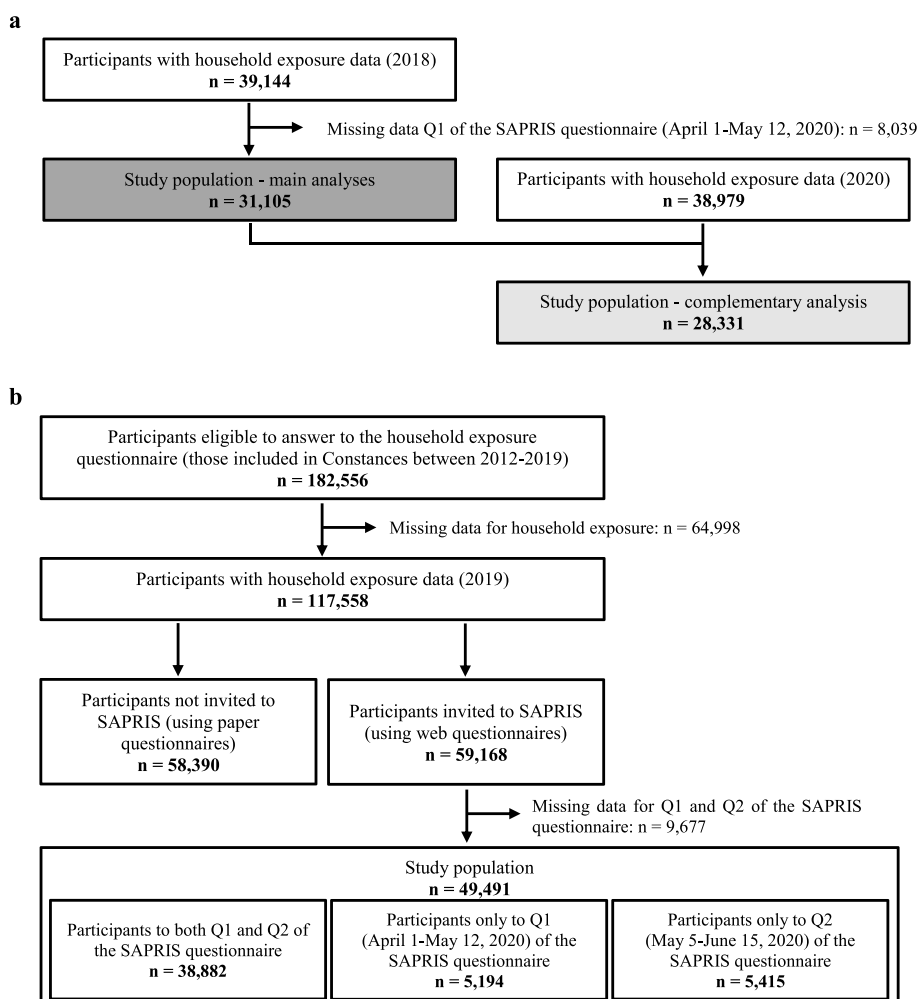


Fig. 1 a Flowchart of the study population in the NutriNet-Santé cohort. b Flowchart of the study population in the CONSTANCES cohort

questionnaires related to household cleaning habits and the SAPRIS web questionnaire.

Household cleaning habits in 2018–2019 and during the first lockdown period (2020)

Household cleaning habits in the last 12 months were evaluated by the same standardized self-administered questionnaire in the two cohorts, asked twice in NutriNet-Santé (in 2018 and May–October 2020) and once in CONSTANCES (in 2019). This questionnaire collected information on the household help (yes/no according to the answer to the question “Are you getting help to do home cleaning, for example, husband/wife, household employee, family members, friends,...?”), the frequency of home cleaning and the use of several HDCPs (never, <1 day/week, 1–3 days/week, 4–7 days/week) as well as the duration of use of HDCPs (never or <1 day/week, <10 min/week, 10–30 min/week, 30 min–1 h/week, 1–2 h/week, >2 h/week). Questions covered the

use of irritants (bleach, ammonia, acids, solvents), green products and sprays (furniture, glass, floor, bath, oven, ironing, air freshener, insecticide, or other use). In our analyses, the frequency of home cleaning was studied by a binary variable (<1 day/week—reference, ≥1 day/week), the frequency of weekly use of HDCPs was studied with a 3-class variable (<1 day/week—reference, 1–3 days/week, 4–7 days/week) and the duration of use of HDCPs was studied with a 4-class variable (<1 day/week—reference, <10 min/week, 10–30 min/week, >30 min/week).

In the SAPRIS survey, six questions related to household cleaning habits during the first lockdown period in France (March 17 to May 3, 2020) were asked in a single questionnaire in NutriNet-Santé (only Q1: April 1-May 12, 2020) and in two separate questionnaires in CONSTANCES (Q1: April 1-May 12, 2020; Q2: May 5-June 15, 2020). Two of them, common to the household questionnaire (NutriNet-Santé and CONSTANCES), were on household help (yes, no) and the duration of weekly

use of HDCPs (<1 day/week—reference, <10 min/week, 10–30 min/week, >30 min/week) and studied as mentioned above. In addition, in SAPRIS, questions about the person in charge of household tasks (the participant, most often the participant, both the participant and his/her spouse, most often the participants' spouse, the participants' spouse, other family members, both the participant and other family members), the duration of home cleaning (0 min/week, <30 min/week, 30 min–1 h/week, 1–2 h/week, 2–4 h/week, 4–6 h/week, ≥6 h/week) and the frequency of use (unchanged/increased) of HDCPs (i.e., hand sanitizer, white vinegar, bleach, disinfectants, other cleaning products) were asked and used to evaluate these parameters during the lockdown period in both cohorts. The duration of home cleaning was also studied by a binary variable in order to study the frequency of home cleaning (<1 day/week, ≥1 day/week) which was compared with the one reported in 2018/2019.

Statistical analyses

In order to assess the changes in household cleaning habits during the first lockdown period in France, non-parametric tests on matched data were performed in both cohorts. In particular, we compared the frequency of home cleaning, the duration of use of HDCPs and the household help in 2018/2019 and during the first lockdown period (SAPRIS questionnaire) by Bhapkar and McNemar's tests, respectively, to test marginal homogeneity. As cleaning habits might differ according to gender, age and educational level [11], these analyses were stratified by gender (men, women), age (<45 years, ≥45 years), educational level (<high school diploma, high school to 1-year post-secondary, 2–3 years post-secondary, >3 years post-secondary) to evaluate the robustness of the results. Moreover, the frequency of HDCPs use during the lockdown period from before (SAPRIS questionnaire) was compared between men and women by a Chi-squared test.

In addition, in order to evaluate more precisely the changes in frequency of use of HDCPs between 2018 and 2020, a complementary analysis was carried out on 28,331 participants of NutriNet-Santé (Fig. 1a), in which HDCP habits were collected twice (2018 and May–October 2020). With this analysis, we assessed the medium-term effects of the COVID-19 pandemic on the changes in the use of HDCPs, as the changes might be more pronounced during the lockdown period (reflecting the short-term effects), and verified if those changes persisted in the months following.

The analyses in both studies were performed using the statistical analysis software SAS® version 9.4 (SAS Institute, Cary, NC, USA).

Results

Participants of NutriNet-Santé were about 48 years old on average, 75% were women, 12% were current smokers, 32% had a Body Mass Index (BMI) higher than 25 kg/m² and 37% had more than a 3-year university educational level (Table 1). In CONSTANCES, web participants were about 48 years old on average, 51% were women, 13% were current smokers, 39% had a BMI higher than 25 kg/m² and 45% had more than a 3-year university educational level. Regarding household cleaning habits in 2018/2019, 63% of participants of NutriNet-Santé reported cleaning their home weekly, with a weekly use of HDCPs (irritants, sprays, green products) that varied from 30 to 35%. In CONSTANCES, 57% of participants reported cleaning their home weekly and about 32% reported a weekly use of HDCPs. Compared with men, women were significantly younger, never smokers, had a lower BMI, had a higher educational level and reported a more frequent home cleaning and weekly use of HDCPs in both cohorts.

In NutriNet-Santé, compared with participants excluded due to missing data for the SAPRIS questionnaire, included participants were more often men, older, less often current smokers, had a lower BMI and had a higher educational level (Table S1).

In CONSTANCES, compared with participants not invited because they do not usually complete online questionnaires (but paper questionnaires), included web participants were more often men, younger, never smokers, had a lower BMI and had a higher educational level (Table S1). Among those invited, compared with participants excluded due to missing data for SAPRIS questionnaires, included participants were more often women, older, never smokers, had a lower BMI and had a higher educational level.

Comparison of household cleaning habits before and during the first lockdown

For participants of NutriNet-Santé, during the lockdown period compared with 2018, the frequency of home cleaning (99% vs. 63%) and the duration of weekly use of HDCPs increased (>30 min/week: 44% vs. 18%) whereas the household help (5% vs. 40%) decreased (Table S2). According to gender, during the lockdown period, 34% of men (vs. 8% in 2018) and 48% of women (vs. 21%) reported using HDCPs more than 30 min per week and about 5% of men and women (vs. 39% and 41% in 2018, respectively) reported a household help (Table 2). In addition, the duration of weekly use of HDCPs increased regardless of age (Table S3) and educational level (Table S4).

For participants of CONSTANCES, during the lockdown period compared with 2019, the frequency of

Table 1 Population characteristics at inclusion according to gender

	Participants of the NutriNet-Santé study			p	Participants of the CONSTANCES study			p
	Study population n = 31,105	Men n = 7,822	Women n = 23,283		Study population n = 49,491	Men n = 24,288	Women n = 25,203	
Age (years), mean ± s.d	48.2 ± 13.6	53.0 ± 13.0	46.6 ± 13.4	< 0.0001	47.5 ± 13.1	48.7 ± 13.1	46.3 ± 13.1	< 0.0001
Smoking status, %								
Never smoker	50.8	41.2	54.0	< 0.0001	50.8	46.7	54.7	< 0.0001
Ex-smoker	37.2	47.2	33.8		35.9	40.0	32.1	
Current smoker	12.0	11.6	12.2		13.3	13.3	13.2	
BMI (Body Mass Index—kg/m²), %								
< 25	68.1	54.6	72.6	< 0.0001	61.1	52.6	69.2	< 0.0001
[25-30]	23.4	36.4	19.0		29.6	37.6	21.8	
≥ 30	8.5	9.0	8.4		9.3	9.8	9.0	
Educational level, %								
< high school diploma	19.4	25.5	17.8	< 0.0001	13.0	15.5	10.6	< 0.0001
high school to 1-year post-secondary	15.9	12.6	16.9		14.2	13.7	14.6	
2–3 years post-secondary	28.0	22.5	29.7		27.9	23.9	31.8	
> 3 years post-secondary	36.7	39.4	35.6		44.9	46.9	43.0	
Household cleaning habits, %								
Home cleaning	62.7	40.6	70.1	< 0.0001	56.9	46.0	67.3	< 0.0001
Irritants	34.6	17.5	40.4	< 0.0001	32.6	24.1	40.6	< 0.0001
Sprays	29.6	20.1	32.7	< 0.0001	33.8	27.5	39.7	< 0.0001
Green products	31.2	16.5	36.4	< 0.0001	32.8	24.7	40.5	< 0.0001

Sociodemographic characteristics were assessed at the inclusion. The household cleaning habits (home cleaning and the weekly use of cleaning products) were assessed at the follow-up in 2018 and 2019, respectively in the NutriNet-Santé and the CONSTANCES studies. Comparison of men and women by Chi-squared tests for categorical variables and t-tests for continuous variables (age)

home cleaning (100% vs. about 57%) and the duration of weekly use of HDCPs increased (> 30 min/week: 63% vs. 16%) whereas the household help decreased (3% vs. 56%) (Table S2). According to gender, during the lockdown period, 54% of men (vs. 11% in 2019) and 71% of women (vs. 20%) reported using HDCPs more than 30 min per week and 2% of men (vs. 60% in 2019) and 4% of women (vs. 51%) reported a household help (Table 2). In addition, the duration of weekly use of HDCPs increased regardless of age (Table S3) and educational level (Table S4).

Household cleaning habits during the lockdown period

In NutriNet-Santé, according to the answers to the SAPRIS questionnaire, 55% of participants (49% of men and 57% of women) reported an increased use of HDCPs during the lockdown period (Table 3). In particular, 44% increased their use of hand sanitizer, 35% increased their use of white vinegar, 30% increased both their use of bleach and disinfectants and 32%

increased their use of other cleaning products. The home cleaning was most frequently executed by the participant (34%), both by the participant and his/her spouse (27%) or most often by the participant (26%) and most frequently for 2 to 4 h per week (48%) (Table S2).

In CONSTANCES, according to the answers to the SAPRIS questionnaire, 83% of participants (81% of men and 86% of women) reported an increased use of HDCPs during the lockdown period (Table 3). In particular, 78% increased their use of hand sanitizer, 63% increased their use of white vinegar, 54% increased their use of bleach, 60% increased their use of disinfectants and 66% increased their use of other cleaning products. The home cleaning was most frequently executed both by the participant and his/her spouse (39%), most often by the participant (24%) or most often by the participants' spouse (19%) and the most frequently for 1 to 2 h per week (40%) (Table S2).

Table 2 Household cleaning habits in 2018/2019 and since the lockdown period according to gender

	Participants of the NutriNet-Santé study, n = 31,105				Participants of the CONSTANCES study, n = 49,491				
	Men n = 7,822		Women n = 23,283		Men n = 24,288		Women n = 25,203		
	In 2018	Lockdown	p	In 2018	Lockdown	p	In 2019	Lockdown	p
Household help, %		Q1 ^a			Q1 ^a			Q1 ^a	
Yes	38.6	4.9	<0.0001	40.7	5.5	<0.0001	59.9	2.1	<0.0001
No	61.4	95.1		59.3	94.5		40.1	97.9	
Duration of use, %		Q1 ^a			Q1 ^a			Q2 ^b	
< 1 day/week	56.7	27.6	<0.0001	37.3	21.2	<0.0001	11.4	5.4	<0.0001
< 10 min/week	22.4	16.3		21.7	12.4		53.4	14.9	
10–30 min/week	13.1	21.6		19.8	18.8		24.3	25.4	
> 30 min/week	7.8	34.5		21.2	47.6		10.9	54.3	

^a Q1 questionnaire was asked from April 1 to May 12, 2020 during the first lockdown period in France (March 17 to May 3, 2020)

^b Q2 questionnaire was asked from May 5 to June 15, 2020 right after the first lockdown period in France

The question about the duration of weekly use of HDCPs was asked at two different time-points in NutriNet-Santé (Q1: April 1–May 12, 2020) and in CONSTANCES (Q2: May 5–June 15, 2020). Comparison of household cleaning habits in 2018/2019 and during the first lockdown period in France (March 17 to May 3, 2020) by a McNemar's test for household help and by a Bhapkar test for the duration of weekly use of HDCPs

Table 3 Frequency of use of HDCPs since the lockdown period

	Participants of the NutriNet-Santé study—Q1				Participants of the CONSTANCES study—Q2			
	Study population n = 31,105	Men n = 7,822	Women n = 23,283	p	Study population n = 49,491	Men n = 24,288	Women n = 25,203	p
Self-reported change in frequency of use¹, %								
Unchanged	45.3	51.2	43.4	<0.0001	16.6	19.1	14.2	<0.0001
Increased ²	54.7	48.8	56.6		83.4	80.9	85.8	
Hand sanitizer, %	44.0	39.2	45.7	<0.0001	78.5	75.6	81.3	<0.0001
White vinegar, %	34.6	25.8	37.6	<0.0001	63.3	54.7	70.6	<0.0001
Bleach, %	29.7	23.9	31.8	<0.0001	54.0	45.3	61.9	<0.0001
Disinfectants, %	30.4	24.9	32.4	<0.0001	60.3	56.0	64.8	<0.0001
Other cleaning products, %	32.1	24.6	34.7	<0.0001	66.0	60.5	71.2	<0.0001

The question about the frequency of use of HDCPs was asked at two different time-points in NutriNet-Santé (Q1: April 1-May 12, 2020) and in CONSTANCES (Q2: May 5-June 15, 2020)

¹ The possible answers to this question appeared differently in the two cohorts as participants of NutriNet-Santé must answer positively before the list of products appears in a sub-question (Figure S1a), whereas participants of CONSTANCES can directly indicate which products were used more frequently (Figure S1b)

² Increased use: participants who reported an increased use of at least one of the five HDCPs studied (hand sanitizer, white vinegar, bleach, disinfectants, other cleaning products). Comparison of men and women by Chi-squared tests

Table 4 Comparison of household cleaning habits in 2018 and 2020—NutriNet-Santé

Participants of the NutriNet-Santé study n = 28,331	Household exposure questionnaire of 2018	Household exposure questionnaire of 2020 after lockdown period	p
Household help, %	39.7	41.6	<0.0001
Home cleaning, %			
< 1 day/week	37.4	30.4	<0.0001
1–3 days/week	47.3	50.4	
4–7 days/week	15.3	19.2	
Irritants, %			
< 1 day/week	65.6	78.6	<0.0001
1–3 days/week	28.7	17.5	
4–7 days/week	5.7	3.9	
Sprays, %			
< 1 day/week	70.7	66.5	<0.0001
1–3 days/week	21.6	23.5	
4–7 days/week	7.7	10.0	
Green products, %			
< 1 day/week	69.2	68.1	<0.0001
1–3 days/week	23.9	24.4	
4–7 days/week	6.9	7.5	
Duration of use, %			
< 1 day/week	42.7	39.6	<0.0001
< 10 min/week	22.0	20.4	
10–30 min/week	17.9	19.4	
> 30 min/week	17.4	20.6	

Comparison of household cleaning habits in 2018 and in May–October 2020: by a McNemar’s test for household help and by Bhapkar tests for the frequency of home cleaning, the frequency of weekly use of cleaning products and the duration of weekly use of cleaning products

Comparison of household cleaning habits in 2018 and 2020 in the NutriNet-Santé study

In May–October 2020 compared with 2018 (Table 4), participants of NutriNet-Santé reported a slightly more often household help (42% vs. 40%; $p < 0.0001$), a more frequent weekly home cleaning (70% vs. 63%; $p < 0.0001$), a more frequent weekly use of sprays (33% vs. 29%; $p < 0.0001$) and green products (32% vs. 31%; $p = 0.0005$) but a less frequent weekly use of irritants (21% vs. 34%; $p < 0.0001$), and a longer use of HDCPs (> 30 min/week: 21% vs. 17%). As shown in Table S5, participants reported in particular an increased use of bleach (17% vs. 14%) and sprays for furniture (14% vs. 9%) in 2020 compared with 2018 but a decreased use of acids (4% vs. 25%).

Discussion

Summary of findings

In this longitudinal analysis of data from both NutriNet-Santé and CONSTANCES, the duration of use of HDCPs increased and the household help decreased during the first lockdown period in France compared with 2018/2019, for both men and women. Since the beginning of the lockdown period, a majority of participants reported an increased use of HDCPs, including hand sanitizer, white vinegar, bleach, disinfectants and other cleaning products. A higher proportion of participants of CONSTANCES reported an increase in the frequency of home cleaning and in the use of HDCPs than those from NutriNet-Santé. The complementary analysis performed on data from NutriNet-Santé further showed that participants reported a more frequent use of sprays and green products but a less frequent use of irritants (except for bleach whose use has increased) in 2020, compared with their use in 2018.

Comparison with other studies

To our knowledge, our study is the first to compare the use of HDCPs before and during the COVID-19 pandemic with a longitudinal design. Indeed, studies documenting the use of HDCPs since the pandemic were either retrospective analyses using data from National Poison Control Centers [13–22] or cross-sectional surveys [23–28], and none specifically assessed changes in the frequency of home cleaning, the duration of use of HDCPs or the household help. Therefore, we cannot directly compare our results with those of previous literature. Results based on data of the SAPRIS questionnaire were consistent with those of cross-sectional surveys identified on this topic [23–28], as participants reported an increased use of HDCPs during the lockdown period. In particular, participants of NutriNet-Santé and CONSTANCES cohorts reported a higher use of hand sanitizer [13, 16, 18–22], white vinegar [19], bleach [13, 16,

19, 20], disinfectants [13–15, 18, 21, 22] and other cleaning products, which is consistent with data collected by National Poison Control Centers which indicated an increased number of calls for exposure to these products.

Moreover, based on NutriNet-Santé data, we observed a slight increase from 2018 to May–October 2020 in the use of sprays and green products but a less frequent use of irritants (except bleach). In the SAPRIS questionnaire, we could not study the increased use of sprays and green products, so we cannot conclude if their increase is directly related to the COVID-19 pandemic or if it reflects the changes previously observed [11, 32] in cleaning habits that pursue during the pandemic. However, for the use of bleach, we observed an increased use during the lockdown period, which persisted the months following, that is consistent with WHO guidelines regarding disinfection of environmental surface at home [6]. It would then be interesting to evaluate once again the use of HDCPs, including bleach, in order to study the long-term effects of the COVID-19 pandemic on cleaning habits and of these changes on respiratory health.

Participants of the two cohorts are not quite comparable as there are more women (75% vs. 51%) and participants with a lower educational level in the NutriNet-Santé e-cohort compared with the web population of CONSTANCES. Although our results on the evolution of HDCP use linked to the COVID-19 pandemic lead to the same conclusions, the increased use observed in NutriNet-Santé was lower than in CONSTANCES, especially regarding the frequency of use of HDCPs. One of the reasons for this difference could be that participants answered to these SAPRIS questions at different periods (NutriNet-Santé: April/May (Q1); CONSTANCES: in May/June (Q2)). As WHO guidelines regarding cleaning and disinfection of environmental surfaces during the COVID-19 pandemic [6] were published on May 15, 2020 (after SAPRIS Q1), participants of CONSTANCES might have more importantly increased their frequency and duration of use of HDCPs, than participants of NutriNet-Santé, as a result of the preventive measures communicated. In addition, the choice in answers to the question “Since the lockdown period, do you use some cleaning products more frequently?” did not appear in the same way in NutriNet-Santé (Figure S1a) and in CONSTANCES (Figure S1b). Indeed, in CONSTANCES, participants could directly indicate which products were used more frequently among the five products proposed (hand sanitizer, white vinegar, bleach, disinfectants, other cleaning products), whereas participants of NutriNet-Santé had to positively answer to the main question before a list of the five products appears in a sub-question. Therefore, the answers of participants of the two cohorts regarding the increase in the frequency of use of

specific products are not directly comparable. As results were similar after stratifications by gender, age, and educational level, the difference observed between NutriNet-Santé and CONSTANCES may not be attributed to these socio-demographic parameters. Moreover, in NutriNet-Santé, participants were recruited on a voluntary basis, whereas participants in CONSTANCES were randomly selected, so our results could be influenced by a selection bias.

Strengths and limitations

The current study has strengths and limitations. The main strength of our study is the use of data from two large population-based cohorts, as well as the use of data from the SAPRIS survey which was one of the first surveys set up right after the beginning of the pandemic. These data allowed us to carry out the first longitudinal study documenting changes in the use of HDCPs during the first lockdown period, using non-parametric tests on matched data regarding household cleaning habits in both 2018/2019 questionnaire and the SAPRIS questionnaire (in 2020). We also had enough statistical power to study changes in the use of HDCPs separately in men and women, and considering age and educational level. In addition, in France, preventive measures and public health messaging were uniformly implemented and communicated across the country, without any specific regional variations. One limitation of our study is the assessment of changes in the use of HDCPs based on self-reported data, which could have induced recall bias or self-reporting inaccuracies. Moreover, based on questionnaire data, it is not possible to distinguish the different application modes by which HDCPs were used, nor their chemical composition. Another source of bias could be the selection criteria, especially since participants included in our study differ from those excluded, in both NutriNet-Santé and CONSTANCES. Although occupational and household use of disinfectants and cleaning products is associated with adverse respiratory health effects [11, 12], we could not study the associations between the observed changes in the use of HDCPs and adult's current chronic respiratory diseases because such health data was not available in SAPRIS [4]. Another limitation of our study is that our population only includes participants who usually complete online questionnaires (most participants of NutriNet-Santé, but only 50% of the participants of CONSTANCES) and these participants are not quite representative (high educational level) of the French population.

Future research directions

On a public health point of view, the risks for chronic respiratory diseases of using HDCPs are increasingly

well established [11, 12]. We observed that the COVID-19 pandemic has indeed impacted household cleaning habits, as the use of HDCPs has increased both in frequency and duration of use. Beyond the evaluation of the specific respiratory health effects attributed to the changes that occurred during the pandemic, future longitudinal epidemiological studies should take into account the increase in the use of HDCPs in statistical analyses in order to better assess the health risks linked to the use of HDCPs. Improving research on the hazardous effects of HDCPs, using repeated data on exposure and disease [34], could allow the development of preventive measures in order to reduce worldwide morbidity.

Conclusions

For the first time, we observed a significant increase in the duration of weekly use of HDCPs in two large population-based cohorts. In particular, there was an increase in the use of hand sanitizer, white vinegar, bleach, disinfectants and other cleaning products during the lockdown period. The use of sprays and green products has also increased in 2020 compared with 2018. In order to evaluate the potential impacts of these household changes on health, especially on respiratory health, further longitudinal studies are needed with repeated assessment of the use of HDCPs and respiratory health.

Abbreviations

BMI	Body Mass Index
HDCPs	Household Disinfectant and Cleaning Products
SAPRIS	"Santé, Perception, pratiques, Relations et Inégalités Sociales en population générale pendant la crise COVID-19"
WHO	World Health Organization

Supplementary Information

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Supplementary Material 1.

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Authors' contributions

EPDS, OD and NLM developed the study hypotheses, and contributed to data interpretation, primary manuscript preparation and critical revision of the manuscript. EPDS conducted the statistical analyses. RV, MG, CP, CR, FC, MT, MZ, OD and NLM contributed to acquisition and interpretation of the data and critical revision of the manuscript. RV, LO, EW, LKF, RN, were involved in the data interpretation and critical revision of the manuscript. All authors approved the final version of the manuscript. All authors have read and agreed to the published version of the manuscript.

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Availability of data and materials

Researchers from public institutions can submit a collaboration request including information on the institution and a brief description of the project to collaboration@etude-nutrinet-sante.fr. 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. Data are available on reasonable request. Anonymised data will be shared by request to the CONSTANCES scientific committee.

Declarations

Ethics approval and consent to participate

Electronic informed consent is provided by each individual included in the NutriNet-Santé cohort, which is registered at <https://clinicaltrials.gov/ct2/show/NCT03335644>, conducted according to the Declaration of Helsinki guidelines and approved by the Institutional Review Board of the French Institute for Health and Medical Research (IRB-Inserm) and the "Commission Nationale de l'Informatique et des Libertés" (CNIL n°908450/n°909216). The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. All procedures were approved by the Institutional Review Board of the French Institute of Health (INSERM). The Constances Cohort study has also been approved by the French Data Protection Authority ("Commission

Nationale de l'Informatique et des Libertés", CNIL). Written informed consent was obtained from all participants.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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