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Research Article

Comparison of Usage Patterns of Cosmetic Products During and Outside Pregnancy and Exposure to Body Care Products

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Abstract

Although considered as a population at risk, usage patterns of cosmetic products by pregnant women are not well investigated. The first part of this study was dedicated to the data collection on consumption of 37 Personal Care Products (PCPs) in French pregnant women during and outside pregnancy. The second part was performed to obtain data for the exposure assessment of 2 of these PCPs. Prevalence and frequencies of use were compared to highlight potential discrepancies in consumption before and during pregnancy. 199 pregnant women completed a web questionnaire about their usage patterns of cosmetics. 46 women of this panel took part to a complementary study to collect data on the amount applied and the other data necessary to the exposure assessment of body moisturizers and anti-stretchmark products. When comparing the data collected before and during pregnancy, statistically significant differences were observed for the prevalence of use of 7 PCPs and the frequencies of use of 19 PCPs. The P90 exposure of pregnant women to body moisturizers and anti-stretchmark care were 84.63mg/kg bw/day and 60.91mg/kg bw/day respectively. The results obtained show that women adapt their consumption of cosmetic products while pregnant and give new exposure data for pregnant women.

Keywords: Pregnant women, Cosmetic products, Usage patterns, Consumption data

Abbreviations: PCPs: Personal Care Products; P90: 90th Percentile; P95: 95th Percentile; SCCS: Scientific Committee on Consumer Safety; US EPA: United States Environmental Protection Agency

Introduction

As specified by the European Regulation (EC) n°1223/2009 a cosmetic product placed on the market must be safe for consumer health. In this regulation, pregnant women are classified as a vulnerable population [1], thus a specific risk assessment based on accurate consumption and exposure data is required.

Undoubtedly, pregnancy is a period characterized by many changes particularly at the physiological and physical levels. These modifications can have a particular impact on the state of the skin. Among the most common alterations of the skin, there are changes of pigmentation [2], such as localized hyperpigmentation, or development of striae distensae on different part of the body [3]. Thus, it could be possible that in response to those modifications, pregnant women adapt their consumption of cosmetic products by stopping or beginning the use of products. There is also the possibility that they just change their frequency of use, or the amount of product applied.

Pregnancy is also a critical period in term of exposure to chemicals. Indeed, the use of cosmetics by pregnant women implies a potential exposure of the unborn child to chemical compounds via foeto-maternal exchanges. Since a few years, consumers are informed by the media of the potential presence of hazardous chemicals, such as substances suspected to be endocrine disrupters, in cosmetics. It is therefore highly possible that pregnant women will also vary their consumption in response to this information.

Some publications provide little information on consumption of cosmetic products by this specific population. For most of them, the first objective of the study is not to collect consumption data, but to assess the presence of controversial substances (phthalates) in urinary sample of pregnant women. To fulfill this objective, participants are asked about their use of cosmetic products during the 24 or 48 hours prior urinary sample collection. Indeed, percentage of users of different types of cosmetic products among pregnant women and sometimes frequencies of use, are generated during these studies [4-8]. In the paper of *Ficheux, et al.* [9], concerning frequencies of use of cosmetic products by the French population, 251 pregnant women were included in the panel. As a result, frequencies of use of 98 personal care products by pregnant women were obtained [9].

Other studies have been performed to identify changes in usage pattern of cosmetics by women during pregnancy. In a study carried out in France, the authors have analyzed the proportion of women changing their use of cosmetic products during pregnancy or considering doing so in case of pregnancy [10]. 128 women took part to this study, 60 were non-pregnant and 68 were pregnant. 45% of the investigated women believe that there is no risk to use cosmetic products during pregnancy. Among the 28 cosmetics studied, a modification of usage patterns was observed for 5 products during the period of pregnancy [10]. In *Lang, et al.* [11], the consumption of 13 cosmetic product categories was studied to assess variations in their consumption among 80 women from the first trimester of pregnancy to 2-3 months postpartum. Prevalence and frequencies of use data were collected during this study. However, no information on quantities of cosmetics applied was generated [11].

The first part of this study consisted of the collection of data on consumption of personal care products by pregnant women such as percentage of users and frequency of use. To detect potential modifications in usage patterns of cosmetic products during pregnancy, information concerning the period preceding pregnancy and the period of pregnancy was collected. The second part of the study was dedicated to the collection of real-time consumption data such as quantity applied per day and per use and frequencies. Those data were then used to perform an exposure assessment of two cosmetic products widely used by pregnant women in Europe, i.e., body moisturizers and anti-stretchmark care.

Materials and Methods

First Part: Consumption Survey

Survey's design: The aim of this survey was to collect data on pregnant women consumption of cosmetic products during and outside pregnancy to identify possible changes in consumption habits between those 2 periods. A questionnaire survey developed by the safety assessment department of Pierre Fabre Dermo Cosmetic and Euro safe laboratory, in association with the Premup foundation was conducted between September 2017 and December 2018 in France. To recruit pregnant women, posters and flyers were displayed in waiting rooms of 12 maternity wards in France and 2 gynecologic offices in Ille-et-Vilaine department. Pregnant women already enrolled in clinical study panels conducted by Euro safe (Ille-et-Vilaine) were also recruited. The objective of the survey, as well as the website and a QR Code allowing an easy access to the survey questionnaire, were specified on posters and flyers. A diagram presenting the process of this consumption survey is provided in (Figure 1).

This form was developed to obtain data on the consumption of 37 personal care products. Among the cosmetics studied, 15 body products (hygiene: 4; care: 9 and perfuming: 2), 13 face products (hygiene: 4; care: 5 and make-up: 4), 4 hair products, 2 oral care products and 3 sun products were selected (Table 1). The aim was to determine for each product investigated, the prevalence and frequency of use of common cosmetics by women, before and during the period of pregnancy. Women surveyed were asked to report their frequency of use during and out of the pregnancy period. As women were pregnant during the survey completion, responses given for the period preceding pregnancy were based on a recall. Four scale of frequency were proposed according to the product (Table 1):

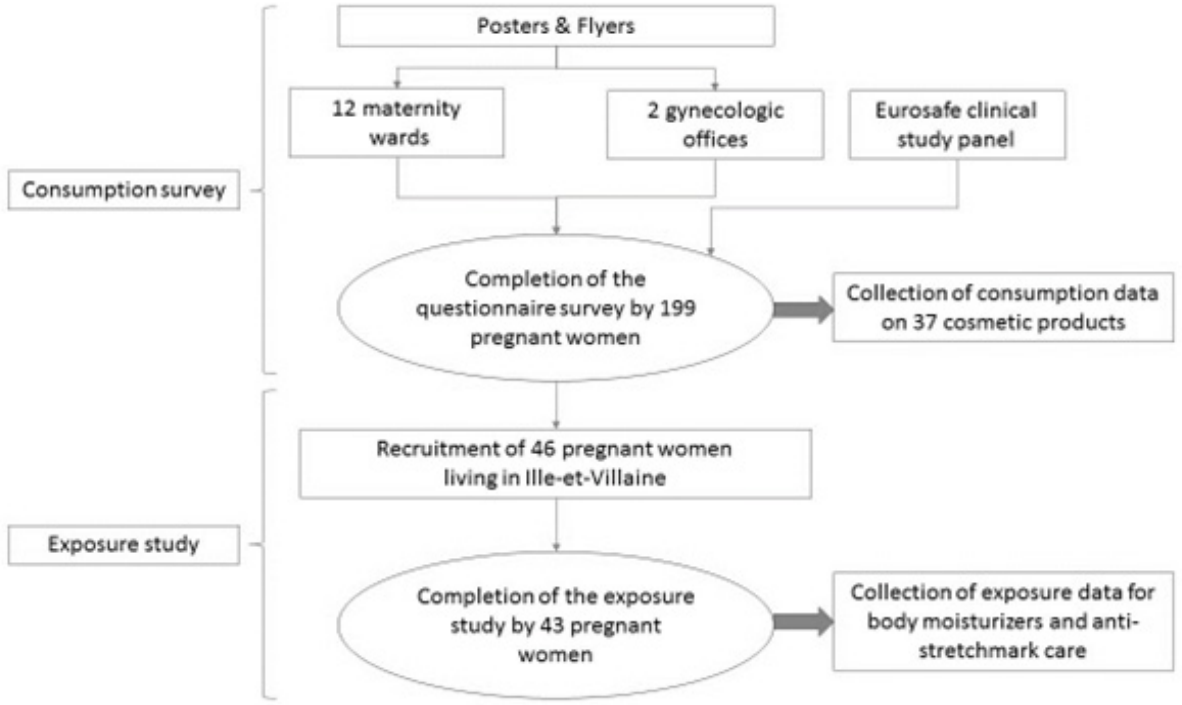

Figure 1: Survey's design.

Table 1: Frequency scale and investigated products.

Product Types		N	Frequency scale			
			1	2	3	4
Body	Hygiene	4	Shower gel; Soap; Intimate hygiene; Deodorant			
	Care	9	Moisturizing care; Bust care; Anti-stretchmark care; Slimming care; Massage oil; Hand cream; Foot cream	Nail polish; Nail polish remover		
	Perfuming	2	Eau de toilette; Perfume			
Face	Hygiene	4	Cleansing gel; Soap; Exfoliating scrub; Make-up remover			
	Care	5	Moisturizing care; Eye contour; Anti-wrinkle care; Depigmenting care	Mask		
	Make-up	4	Foundation; Mascara; Eye pencil; Lipstick			
Hair		4	Shampoo; Conditioner; Hair styling		Hair dye	
Oral care		2	Toothpaste; Mouthwash			
Sun		3			Self-tanner	Face sunscreen; Body sunscreen
Total		37				

A. Scale 1: Never, <once a month, once a month, 2-3 times a month, once a week, 2-4 times a week, once a day, twice a day, 3 times a day and 4 times a day. The respondents answering a frequency of "Never" or "<once a month" were considered as non-users.

B. Scale 2: Never, <5 times a year, 5 times a year, 6-10 times a year, once a month, 2-4 times a month, once a week, twice a week, three times a week and 4 times a week. The respondents answering a frequency of "Never" or "<5 times a year" were considered as non-users.

C. Scale 3: Never, <5 times a year, 5 times a year, 6-10 times a year, once a month, twice a month, 3 times a month. The respondents answering a frequency of "Never" or "<5 times a year" were considered as non-users.

In the cases of face and body sunscreen, the frequencies of use were asked in a context of holidays, thus a particular scale (scale 4) was used: ≤ once a week, 2-4 times a week, once a day, twice a day, 3 times a day and 4 times a day. Women also had to specify the extent of the period of use over a year: Never, <a month, 1-2 months, 3-4 months, 4-5 months, >6 months, all over the year.

Demographic data (age, living place, socio-professional category, professional situation) and pregnancy data (trimester of pregnancy, number of children) were collected (Table 2). Information on the places where women purchased their cosmetic products, and their selection criteria was also recorded (Table 2).

Table 2: Characteristics of the population recruited.

Consumption survey		
Characteristics	**N (Total=199)**	**Percentage of the panel**
Age (years old)		
< 30	77	38.7 %
30 to 39	113	56.8 %
≥ 40	9	4.5 %
Professional situation		
Inactive	7	3.5 %
Active	116	58.3 %
Maternity leave	76	38.2 %
Socio-professional category		
Employee	91	45.7 %
Executive or equivalent	74	37.2 %
Intermediate occupation	13	6.5 %
Shopkeeper, craftman, businessman	4	2.0 %
Inactive	7	3.5 %
Other	10	5.0 %
Trimester of pregnancy		
First	13	6.5 %
Second	78	39.2 %
Third	108	54.3 %
First pregnancy		
Yes	99	49.7 %
No	100	50.3 %
Number of children		
1	62	31.2 %
2	29	14.6 %
3	8	4.0 %
Living area		
Bretagne	89	44.7 %
Normandie	2	1.0 %
Haut-de France	8	4.0 %
Ile de France	74	37.2 %
Grand Est	18	9.0 %
Centre-Val de Loire	4	2.0 %
Occitanie	4	2.0 %

Exposure study		
Characteristics	**N (Total= 43)**	**Percentage of the panel**
Age (years old)		
< 30	16	37.2 %
30 to 39	25	58.1 %
≥ 40	2	4.7 %
Trimester of pregnancy		
First	1	2.3 %
Second	20	46.5 %
Third	22	51.2 %
Body weight (Kg)		
< 60	14	32.6 %
[60-80[	22	51.2 %
[80-100[	6	14.0 %
≥ 100	1	2.3 %

Population studied: There was no sampling plan set-up for this enquiry. The internet questionnaire was accessible to all adult pregnant women (≥18 years old) who wanted to answer it, regardless of the stage of pregnancy. The panel formed was composed of 199 pregnant women from 19 to 52 years old, with the mean age being 31 years old.

Data Analyses: The data were analyzed to identify possible changes in consumption habits between the period of pregnancy and outside the pregnancy. Descriptive statistics were used for the analysis of demographic data and general information on the population studied.

- **Prevalence of use:** A khi2 test was used to compare the percentages of users of each cosmetic product during pregnancy and out of this period. Variations of the percentages between the two periods were also calculated.

- **Frequency of use:** The possible responses proposed thanks to the different scales were converted to obtain daily frequencies. For example, if the respondent stated a frequency of "2-3 times a month", this one was converted in 2.5/30 day^{-1}. A frequency of 2/7 day^{-1} was attributed in replacement of a "twice a week" frequency of use. For each product, mean, standard deviation and the 90^{th} percentile (P90) of the frequency of use were obtained with the @Risk 7.6 software (Palisade Corp.). When the dataset was enough for a product (N≥10), statistical comparisons were performed between frequencies obtained before and during pregnancy, using the non-parametric Wilcoxon test for paired samples. The variation between the period preceding pregnancy and pregnancy was then calculated.

- **Number of different products used per day:** The frequencies of use per day filled for each product by each respondent were added to obtain an estimation of the number of different cosmetics used per day by each respondent. In the case of product with a daily frequency of use over 1, the default value of once a day was applied.

- **Purchasing places and selection criteria:** The distributions of pregnant women according to places where they purchased cosmetic products were calculated for the two periods studied. In addition, each interviewee ranked 3 criteria they considered the most important for the selection of personal care products. A score of 3 points was attributed for the criterion ranked at the 1^{st} place, 2 points for the 2^{nd} and 1 point for the 3^{rd}. Scores obtained thanks to the responses of each participant were then added to calculate a global score for each criterion, before and during pregnancy.

All the statistical analysis was performed with the Stat Tools 7.6 software (Palisade Corp.) and statistical differences were considered significant when p-value <0.05.

Second Part: Exposure Study

Study's design: Among the 199 pregnant women recruited for the survey on consumption of cosmetic products, women living in the French department of Ille-et-Vilaine (35) were asked to participate to a complementary study on exposure to 2 personal care products during pregnancy. The recruitment was limited to this geographical area because participants were asked to bring their personal products (new bought) to Euro safe laboratory so that they were weighed at the beginning and end of a 21-day period. The products investigated were body moisturizer and anti-stretchmark care (Figure 1).

Participants were asked to use those products as usual. To obtain frequencies of use, pregnant women had to record each application daily in a follow-up form. They also had to fill out the galenic form (oil, cream, milk) of the product they used, the body part of application and their body weight at D0 of the study. An informed consent form was completed and signed by participants before the study began.

Population studied: 46 pregnant women took part at the beginning of the study. However, there was one withdrawal, and two other participants gave birth before the end of the 21 days. Thus, 43 participants from 25 to 45 years old with the mean age being 31 years old were involved and completed the study (Figure 1). Among those women, one did not return a moisturizer she used for the final weighing. All the data collected for this participant were kept, except data concerning moisturizers.

Exposure assessment: The following equation was used to assess pregnant women exposure to the cosmetic products investigated thanks to data collected in this exposure study:

$$\text{Exposure}\left(mg/kgbw/day\right)=\frac{F\times A\times RF}{BW},with:$$

F=Frequency of use (day^{-1})

A=Amount of product (mg)

RF=Retention factor

BW=Body Weight (kg bw)

Amount, frequency, and body weight data were adjusted to theorical distribution in the @Risk 7.6 software (Palisade Corp.) to obtain mean, median, standard deviation, 90th percentile (P90) and 95th percentile (P95). This software was then used to run 10,000 iterations using Monte Carlo random simulation to perform a probabilistic exposure assessment, according to United States Environmental Protection Agency (U.S.EPA) recommendations [12]. As the 2 cosmetic products investigated are leave-on products, a retention factor of 1 was applied in exposure calculation. The exposure assessment was performed for all combined form of body moisturizer and anti-stretchmark care for all the respondents. Moreover, the number of data collected allow to assess separately the exposure to milk body moisturizers and oily anti-stretchmark care and to consider the trimester of pregnancy (2nd or 3rd).

Results

Consumption Survey

Characteristics of the population: The population recruited was composed of 199 pregnant women principally living in the north of France. Their principal characteristics are presented in (Table 2). More than half of the population was aged between 30 to 39 years old (56.8%) and was still working during the study (58.3%). The panel was equally divided between women who were pregnant for the first time and women who already experienced a pregnancy, and 54.3 % of the interviewed women completed the enquiry during the 3rd trimester of their pregnancy (Table 2).

Prevalence of use: Percentages of users before and during pregnancy were calculated for the 37 investigated cosmetic products (Table 3). Statistically significant differences (p-value <0.05) were observed between the prevalence of use before and during pregnancy for 7 products. Among them, the number of users increased for 2 body care: bust care (+21.6%) and anti-stretchmark care (+65.3%), whereas it decreased for the 5 others following products: slimming care (-9%), nail polish (-23.6%), nail-polish remover (-21.6%), perfume (-13.1%) and mask (-13.1%). All in all, the percentage of users increased for 7 products and decreased for 27 during the period of pregnancy, even if the results are not always statistically significant. There was no variation of the prevalence of use for 3 products between the two periods: depigmenting care, shampoo, and toothpaste (Table 3).

Table 3: Comparison of percentages of users before and during pregnancy.

Product		Percentage of users before pregnancy (N)	Percentage of users during pregnancy (N)	Variation (% before - % during)
Body hygiene	Shower gel	93.0 % (185)	91.5 % (182)	-1.5 %
	Soap	43.7 % (87)	46.2 % (92)	+2.5 %
	Intimate hygiene	49.2 % (98)	55.8 % (111)	+6.5 %
	Deodorant	94.5 % (188)	92.0 % (183)	-2.5 %
Body care	Moisturizing care	88.9 % (177)	92.0 % (183)	+3.0 %
	Bust care	10.6 % (21)	32.2 % *** (64)	+21.6 %
	Anti-stretchmark care	5.5 % (11)	70.9 % *** (141)	+65.3 %
	Slimming care	10.6 % (21)	1.5 % *** (3)	-9.0 %
	Massage oil	22.1 % (44)	30.7 % (61)	+8.5 %
	Hand cream	70.9 % (141)	63.3 % (126)	-7.5 %
	Foot cream	26.1 % (52)	24.1 % (48)	-2.0 %
	Nail polish	68.3 % (136)	44.7 % *** (89)	-23.6 %
	Nail polish remover	63.8 % (127)	42.2 % *** (84)	-21.6 %

Perfuming	Eau de toilette	41.2 % (82)	36.2 % (72)	-5.0 %
	Perfume	77.4 % (154)	64.3 % ** (128)	-13.1 %
Face hygiene	Cleansing gel	56.8 % (113)	53.3 % (106)	-3.5 %
	Soap	13.6 % (27)	13.1 % (26)	-0.5 %
	Exfoliating scrub	53.8 % (107)	46.2 % (92)	-7.5 %
	Make-up remover	78.9 % (157)	73.4 % (146)	-5.5 %
Face care	Moisturizing care	78.4 % (156)	79.4 % (158)	+1.0 %
	Eye contour	31.7 % (63)	28.6 % (57)	-3.0 %
	Anti-wrinkle care	23.6 % (47)	21.1 % (42)	-2.5 %
	Depigmenting care	2.0 % (4)	2.0 % (4)	0.0 %
	Mask	52.8 % (105)	39.7 % ** (79)	-13.1 %
Face make-up	Foundation	68.3 % (136)	61.8 % (123)	-6.5 %
	Mascara	84.9 % (169)	78.4 % (156)	-6.5 %
	Eye pencil	61.8 % (123)	55.3 % (110)	-6.5 %
	Lipstick	58.3 % (116)	52.3 % (104)	-6.0 %
Hair	Shampoo	100.0 % (199)	100.0 % (199)	0.0 %
	Conditioner	69.8 % (139)	67.3 % (134)	-2.5 %
	Hair styling	26.1 % (52)	23.1 % (46)	-3.0 %
	Hair dye	17.1 % (34)	10.6 % (21)	- 6.5 %
Oral care	Toothpaste	100.0 % (199)	100.0 % (199)	0.0 %
	Mouthwash	29.1 % (58)	27.6 % (55)	-1.5 %
Sun	Self-tanner	1.5 % (3)	0.5 % (1)	-1.0 %
	Face sunscreen	76.9 % (153)	75.4 % (150)	-1.5 %
	Body sunscreen	86.9 % (173)	80.9 % (161)	-6.0 %
Khi² test: **0.001< p-value ≤ 0.01; ***p-value ≤ 0.001				

Frequency of use: The frequencies of use during and outside the period of pregnancy were calculated with @Risk 7.6 software (Palisade Corp.) for products when the number of users was enough, i.e., N>10 for the mean frequency of use and N>50 for the 90th percentile (Table 4). Indeed, no frequency of use was calculated for slimming care during pregnancy and for depigmenting care and self-tanner for both periods. The number of pregnant women increasing or decreasing their frequency of use during the pregnancy period is also presented in Table 4, as well as the number of those who started or stopped the use of a cosmetic while pregnant. Among the 37 cosmetic products investigated, significant statistical differences were observed between frequencies of use before and during pregnancy for 19 products (Table 4).

Table 4: Comparison of frequencies of use before and during pregnancy.

Product	Frequency of use before pregnancy (day^{-1})				Frequency of use during pregnancy (day^{-1})				Frequency change (N)			
	N	Mean	SD	P90	N	Mean	SD	P90	Increase	Decrease	Stop	Start
Body hygiene												
Shower gel	185	0.97	0.36	1.00	182	0.94	0.40	1.00	3	11	3	0
Soap	87	1.40	1.28	4.00	92	1.44	1.31	4.00	6	2	0	5
Intimate hygiene	98	0.85	0.51	1.00	111	0.91	0.61	2.00	14	6	5	18
Deodorant	188	1.13	0.52	2.00	183	1.10	0.57	2.00	9	18	5	0
Body care												
Moisturizing care***	177	0.88	0.68	2.00	183	1.22	0.72	2.00	75	4	5	11
Bust care**	21	0.51	0.63	-	64	1.03	0.83	2.00	11	1	2	45
Anti-stretchmark care	11	0.78	0.73	-	141	1.17	0.67	2.00	5	0	1	131

Slimming care	21	0.58	0.75	-	3	-	-	-	1	0	20	2
Massage oil**	44	0.20	0.28	-	61	0.65	0.52	1.00	13	3	11	28
Hand cream	141	0.79	0.98	2.00	126	0.81	1.00	2.00	19	8	16	1
Foot cream	52	0.36	0.54	1.00	48	0.34	0.50	-	8	3	9	5
Nail polish*	136	0.07	0.08	0.14	89	0.07	0.09	0.14	8	23	49	2
Nail polish remover*	127	0.07	0.08	0.14	84	0.07	0.08	0.14	8	23	44	1
Perfuming												
Eau de toilette***	82	0.83	0.44	1.00	72	0.73	0.49	1.00	1	18	12	2
Perfume***	154	0.82	0.46	1.00	128	0.68	0.45	1.00	1	36	26	0
Face hygiene												
Cleansing gel*	113	0.94	0.59	2.00	106	0.94	0.58	2.00	0	7	8	1
Soap	27	0.77	0.57	-	26	0.85	0.55	-	1	0	2	1
Exfoliating scrub	107	0.13	0.14	0.14	92	0.13	0.15	0.14	3	10	15	0
Make-up remover***	157	0.87	0.43	1.00	146	0.81	0.48	1.00	2	22	11	0
Face care												
Moisturizing care	156	1.08	0.53	2.00	158	1.09	0.59	2.00	9	12	1	3
Eye contour**	63	0.83	0.59	2.00	57	0.81	0.62	2.00	1	10	7	1
Anti-wrinkle care	47	0.89	0.52	-	42	0.91	0.54	-	0	2	6	1
Depigmenting care	4	-	-	-	4	-	-	-	0	2	0	0
Mask*	105	0.07	0.06	0.14	79	0.07	0.06	0.14	1	9	26	0
Face make-up												
Foundation***	136	0.76	0.35	1.00	123	0.65	0.38	1.00	0	32	15	2
Mascara***	169	0.75	0.38	1.00	156	0.67	0.41	1.00	3	28	13	0
Eye pencil***	123	0.67	0.41	1.00	110	0.59	0.43	1.00	0	23	13	0
Lipstick ***	116	0.68	0.78	2.00	104	0.56	0.70	1.70	1	26	13	1
Hair												
Shampoo***	199	0.46	0.24	1.00	199	0.43	0.24	1.00	0	18	0	0
Conditioner	139	0.32	0.23	0.43	134	0.32	0.24	0.43	2	12	5	0
Hair styling	52	0.46	0.36	1.00	46	0.44	0.35	-	0	5	7	1
Hair dye	34	0.02	0.01	-	21	0.02	0.01	-	0	3	13	0
Oral care												
Toothpaste*	199	1.94	0.62	3.00	199	1.99	0.58	3.00	15	4	0	0
Mouthwash	58	0.38	0.53	1.00	55	0.41	0.61	1.00	5	4	11	8
Sun												
Self-tanner	3	-	-	-	1	-	-	-	0	0	2	0
Face sunscreen***	153	2.02	1.05	3.00	150	2.46	1.13	4.00	56	6	9	6
Body sunscreen***	173	2.05	1.06	3.00	161	2.47	1.10	4.00	52	5	15	3

Wilcoxon test: *0.01< p-value ≤0.05; **0.001< p-value ≤0.01; ***p-value ≤ 0.001; "-" not presented when N< 10 for Mean value and N < 50 for P90 value

Increase: Number of women who increased their frequency of use during pregnancy

Decrease: Number of women who decreased their frequency of use during pregnancy

Stop: Number of women who stopped using the product during pregnancy

Start: Number of women who started using the product during pregnancy

i. Body hygiene: Even if there were differences between frequencies of use for the 4 body hygiene products, these differences were not statistically significant.

ii. Body care: Among the 9 products belonging to this category, statistically significant differences were observed between frequencies of use before and during pregnancy for 5 of

them. The mean frequencies of use for moisturizing care, bust care and massage oil increased from 0.88, 0.51 and 0.20 to 1.22, 1.03 and 0.65 day^{-1} respectively. Statistically significant differences were also observed for 2 other products: nail polish and nail polish remover even if the mean frequencies obtained stayed the same (0.07 day^{-1}). The statistically significant difference is principally due to the high variation in the percentage of users (>20%) between pregnancy and non-pregnancy period. No statistical difference was obtained for anti-stretchmark care because there was a very high difference in the percentage of users before and during pregnancy and the test used was a statistical test for paired samples.

iii. **Perfuming:** Statistically significant decreases of the frequencies of use were observed for the 2 products of this category. The mean frequency of use decreased from 0.83 to 0.73 day^{-1} for cologne and from 0.82 to 0.68 day^{-1} for perfume.

iv. **Face hygiene:** Frequencies of use were obtained for 4 face hygiene products and statistical differences were observed for cleansing gel and make-up remover. The difference was very slight for cleansing gel. A significant decrease was observed for make-up remover, with a mean frequency that has decreased from 0.87 to 0.81 day^{-1}.

v. **Face care:** Among the 5 products of this category, statistically significant differences were observed between frequencies of use before and during pregnancy for 2 of them. The mean frequency of use for eye contour decreased from 0.83 to 0.81 day^{-1}. For mask, the mean frequencies obtained stayed the same (0.07 day^{-1}). This result is principally due to the high variation in the percentage of users (13.1%) during and before the pregnancy period.

vi. **Face make-up:** Statistically significant decreases were observed between frequencies of use between pregnancy and non-pregnancy period for each product investigated. The mean frequencies of use for foundation, mascara, eye pencil and lipstick decreased from 0.76, 0.75, 0.67 and 0.68 day^{-1} to 0.65, 0.67, 0.59 and 0.56 day^{-1} respectively.

vii. **Hair:** Frequencies of use were obtained for 4 hair products. A statistically significant difference was observed only for the shampoo with a decrease of the mean frequency from 0.46 day^{-1} before pregnancy to 0.43 day^{-1} during pregnancy.

viii. **Oral care:** 2 products were investigated for this product category and a statistically significant increase of the frequency of use during pregnancy was observed for toothpaste (from 1.94 to 1.99 day^{-1}).

ix. **Sun:** Frequencies of use were obtained for 2 of the 3 sun products studied and statistically significant decreases were observed between frequencies of use between pregnancy and non-pregnancy period for face and body sunscreen from 0.97 to 0.94 day^{-1} for both.

Number of products used: Among the 37 cosmetics referenced in the questionnaire, women reported to use an average of 19 different products, with a P90 value of 26 before pregnancy and 25 during pregnancy. However, the results show that about 65% of the women interviewed changed their consumption during pregnancy. 41.21% used more and 23.11% used less different products while pregnant. Daily, an average of 12 different products are used by women independently of pregnancy, with a P90 value of 17 cosmetics for the period preceding pregnancy and 18 while pregnant. 40.70% of the panel increased the number of products used daily during pregnancy.

Purchasing places and selection criteria of cosmetic products: The distributions of the purchasing places of the different product categories, before and during pregnancy are presented in Figure 2. Most interviewees preferred to purchase sun, care, and hygiene products in drugstore out of pregnancy and this trend was increased while pregnant. Oral care products are principally purchased in supermarket, with 71% of women buying oral care in those places before pregnancy and 67% while pregnant. 4% of women who used to purchase oral care in supermarket before pregnancy, prefer to buy it in drugstore during their pregnancy. The repartition of the purchasing places of make-up products does not vary a lot. Only 1% of women who used to buy them in supermarket before pregnancy changed for cosmetic/perfume shop during pregnancy.

The scores obtained for the different selection criteria thanks to the responses given by the participants to the survey are presented in Figure 3. The 3 criteria preferred by women out of a pregnancy period are: the presence of natural ingredients, the price, and the brand, with respectively a score of 291, 277 and 203 points. This ranking is modified in the context of pregnancy, the natural ingredients staying the first selection criteria with 386 points, while safety being the second criterion with 265 points, followed by the price (193 points) (Figure 2&3).

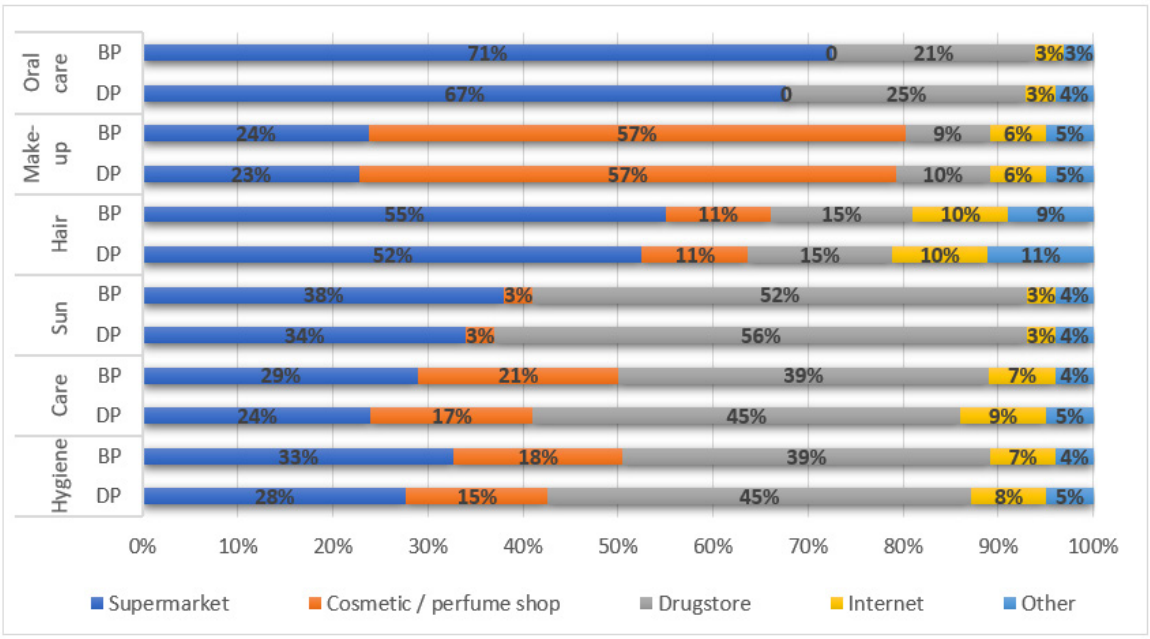

Figure 2: Distribution of purchasing places of cosmetic products.
BP: Before Pregnancy
DP: During Pregnancy

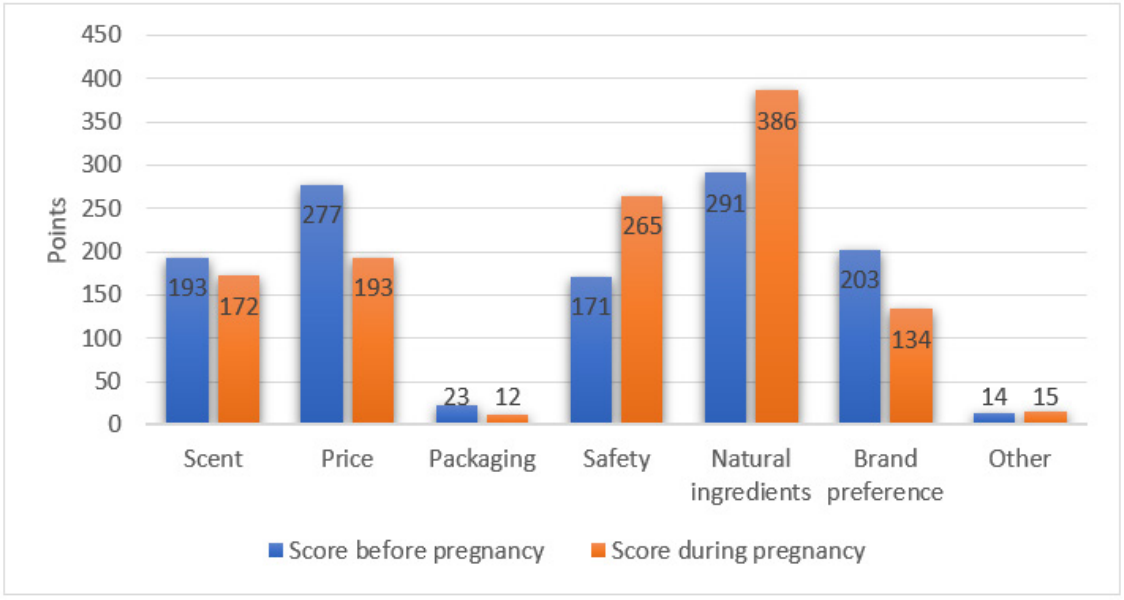

Figure 3: Selection criteria of a cosmetic product.

Exposure Study

Population Studied

The main characteristics of the population recruited for the exposure part of the study are presented in Table 2. 43 pregnant women were involved in the study, among which 58.1% were aged between 30 to 39 years old, and 67.5% presented a body weight over 60kg. The panel is almost equivalently composed of women being at their second or third trimester of pregnancy and only one participant was at her first trimester of pregnancy.

Consumption Data

The percentages of users of body moisturizers and anti-stretchmark care are presented in Table 5. 55.8% of the interviewees used body moisturizers, among which 18.6% used only this type of product while 37.2% used also anti-stretchmark care at the same

time. The panel is composed of 81.4% of users of anti-stretchmark care, divided into 44.2% of women using only this care product and 37.2% of pregnant women using body moisturizers and anti-stretchmark care. The oily form of anti-stretchmark care was preferred to other forms with 74.2% of users. Among the different kind of body moisturizers, the milk form was the most represented with 45.8% of users. When used alone, body moisturizers are mostly applied on the lower part of the body, 87.5% of the subjects used it on the belly, 62.5% used it on the thighs and 50% on the legs. Anti-stretchmark care used alone, is applied by all women on the belly, by more than 50% on the chest and or buttocks and by 42% on thighs. When women were users of both products, anti-stretchmark care was preferentially applied on the upper part of the body compared to body moisturizer which was mostly used on the lower part of the body (Table 5).

Table 5: Percentages of users by product, product form and area of application.

		Users (N)	Percentage of users
Product			
Body moisturizer (only)		8	18.6 %
Anti-stretchmark care (only)		19	44.2 %
Body moisturizer + Anti-stretchmark care		16	37.2 %
Body moisturizer (total)		24	55.8 %
Anti-stretchmark care (total)		35	81.4 %
Product form			
Body moisturizer (N=24)	Oil	5	20.8 %
	Cream	5	20.8 %
	Milk	11	45.8 %
	Balm	3	12.5 %
Anti-stretchmark care (N=35)	Oil	26	74.2 %
	Cream	5	14.3 %
	Balm	1	2.9 %
	Gel	2	5.7 %
	Serum	1	2.9 %
Area of application			
Body moisturizer only (N=8)	Chest	1	12.5 %
	Neck & Neckline	2	25.0 %
	Arms	1	12.5 %
	Belly	7	87.5 %
	Buttocks	2	25.0 %
	Thighs	5	62.5 %
	Legs	4	50.0 %
Anti-stretchmark care only (N=19)	Chest	10	52.6 %
	Belly	19	100.0 %
	Buttocks	11	57.9 %
	Thighs	8	42.1 %
Body moisturizer + Anti-stretchmark care (N=16)	Chest (Body moisturizer)	5	31.3 %
	Chest (Anti-stretchmark care)	10	62.5 %
	Belly (Body moisturizer)	3	18.8 %
	Belly (Anti-stretchmark care)	16	100.0 %
	Buttocks (Body moisturizer)	7	43.8 %
	Buttocks (Anti-stretchmark care)	5	31.3 %
	Thighs (Body moisturizer)	11	68.8 %
	Thighs (Anti-stretchmark care)	7	43.8 %

Consumption and Exposure Assessment to Body Moisturizer and Anti-Stretchmark Care

The frequencies of use, quantities applied and exposures in term of mean, standard deviation, median, P90 and P95 are presented in Table 6. The results have been obtained by grouping all forms of body moisturizers and anti-stretchmark care. However, as their number were sufficient, data for milky form of body moisturizer and oily form of anti-stretchmark care were also considered separately. Similarly, data for pregnant women at their 2nd or 3rd trimester of pregnancy were considered separately for all type of form of both products (Table 6).

Table 6: Probabilistic consumption and exposure assessment to body moisturizer and anti-stretchmark care.

	Body moisturizer				Anti-stretchmark care			
	All types of form (N=24)	Milk only (N=11)	All types of form		All types of form (N=35)	Oil only (N=26)	All types of form	
			T2 (N=11)	T3 (N=13)			T2 (N=15)	T3 (N=20)
Frequency of use (day^{-1})								
Mean	0.92	0.81	0.87	0.97	1.18	1.11	0.96	1.35
Standard deviation	0.41	0.32	0.47	0.38	0.50	0.48	0.43	0.49
Median	0.84	0.75	0.90	1.00	1.08	1.02	0.90	1.31
P90	1.46	1.24	1.14	1.36	1.83	1.74	1.35	2.00
P95	1.70	1.42	1.55	1.48	2.12	2.03	1.72	2.00
Amount per use (g/use)								
Mean	3.11	2.84	3.06	3.15	1.79	1.63	1.60	1.93
Standard deviation	1.85	0.65	2.25	1.52	1.19	0.82	1.42	0.99
Median	2.67	2.77	2.11	3.20	1.49	1.46	1.06	1.57
P90	5.40	3.70	7.01	5.10	3.23	2.68	2.52	3.26
P95	6.60	4.01	7.37	5.57	4.02	3.18	3.64	3.64
Amount per day (g/day)								
Mean	2.85	2.37	2.30	3.32	2.09	1.75	1.52	2.53
Standard deviation	2.12	1.23	1.46	2.53	1.58	0.95	1.41	1.62
Median	2.28	2.10	2.34	3.20	1.67	1.54	0.83	2.14
P90	5.36	3.94	3.14	6.65	3.96	2.96	3.06	3.88
P95	6.83	4.71	4.33	7.81	5.06	3.56	4.09	5.79
Exposure (mg/kg bw/day)								
Mean	44.23	35.68	37.31	49.61	31.75	26.64	25.11	35.99
Standard deviation	34.64	20.03	25.19	39.12	25.15	15.63	24.52	23.86
Median	34.58	30.99	30.96	39.00	24.99	23.01	17.98	29.81
P90	84.63	61.18	67.74	94.88	60.91	46.35	51.52	64.63
P95	109.28	73.40	84.16	123.41	77.31	55.52	69.60	81.11

T2= 2nd trimester of pregnancy

T3= 3rd trimester of pregnancy

Body moisturizers: Body moisturizers were used on average 0.92 time per day with a P90 value of 1.46 day^{-1}. The frequency of use was higher for women in their 3rd trimester of pregnancy than for women in their 2nd trimester, with a mean frequency of 0.97 day^{-1} (versus 0.87 day^{-1}) and a P90 value of 1.36 day^{-1} (versus 1.14 day^{-1}). The frequency of use obtained for the milk form of body moisturizer was lower with a mean of 0.81 day^{-1} and a P90 value of 1.24 day^{-1}.

The mean amount of body moisturizer applied was 3.11g/use with a P90 value of 5.40g/use or a mean of 2.85g/day with a P90 value of 5.36g/day. The amount applied was higher for women

in their 3rd trimester of pregnancy than for women in their 2nd trimester (except for the P90 of amount per use), with a mean amount of 3.15g/use or 3.32g/day (versus 3.06g/use or 2.30g/day) and a P90 value of 5.10g/use or 6.65g/day (versus 7.01g/use or 3.14g/day). For milk form, the mean amount applied was 2.84g/use with a P90 value of 3.70g/use or a mean of 2.37g/day with a P90 value of 3.94g/day.

The mean exposure of pregnant women to all form of moisturizers was 44.23mg/kg bw/day with a P90 value of 84.63mg/kg bw/day. The exposure to body moisturizer was higher for women in their 3rd trimester of pregnancy than for women in their 2nd trimester, with a mean exposure of 49.61mg/kg bw/day (versus 37.31mg/kg bw/day) and a P90 value of 94.88mg/kg bw/day (versus 67.74mg/kg bw/day). The exposure to milk moisturizer was lower, with a mean exposure value of 35.68mg/kg bw/day and a P90 value of 61.18mg/kg bw/day.

Anti-Stretchmark care: Anti-stretchmark care was used on average 1.18 time per day with a P90 value of 1.83 day^{-1}. The frequency of use was higher for women in their 3rd trimester of pregnancy than for women in their 2nd trimester, with a mean frequency of 1.35 day^{-1} (versus 0.96 day^{-1}) and a P90 value of 2.00 day^{-1} (versus 1.35 day^{-1}). The frequency of use obtained for the oily form of anti-stretchmark care was lower with a mean of 1.11 day^{-1} and a P90 value of 1.74 day^{-1}.

The mean quantity of anti-stretchmark care applied was 1.79g/use with a P90 value of 3.23g/use (mean=2.09g/day; P90=3.96g/day). The amount applied was higher for women in their 3rd trimester of pregnancy than for women in their 2nd trimester, with a mean amount of 1.93g/use or 2.53g/day (versus 1.60g/use or 1.52g/day) and a P90 value of 3.26g/use or 3.88g/day (versus 2.52g/use or 3.06g/day). For oil, the mean amount applied was 1.63g/use with a P90 value of 2.68g/use (mean=1.75g/day; P90=2.96g/day).

The mean exposure of pregnant women to all form of anti-stretchmark care was 31.75mg/kg bw/day with a P90 value of 60.91mg/kg bw/day. The exposure to anti-stretchmark care was higher for women in their 3rd trimester of pregnancy than for women in their 2nd trimester, with a mean exposure of 35.99mg/kg bw/day (versus 25.11mg/kg bw/day) and a P90 value of 64.63mg/kg bw/day (versus 51.52mg/kg bw/day). The exposure to oily anti-stretchmark care was lower, with a mean exposure value of 26.64mg/kg bw/day and a P90 value of 46.35mg/kg bw/day.

Discussion

This study focuses on the specific population of French pregnant women, with the main objective of determining if pregnancy had any influence on consumption of personal care products by women. This study mainly focuses on the prevalence and frequency of use of common cosmetic products, but also provides information on how products are purchased. Furthermore, this work was extended to the exposure assessment of pregnant women to 2 body care products.

Study Design

Studied Cosmetics: The list of products proposed in the questionnaire was not exhaustive. However, to our knowledge, this is the first survey only dedicated to the consumption habits of pregnant women that investigates so many products. 28 products were investigated in the study of *Marie, et al.* [10] and 16 products in the study of *Lang, et al.* [11]. In the present study, 37 common cosmetics were considered from 9 cosmetic product categories. Even if more personal care products could have been included, the response time to the questionnaire would have been increased, which could cause annoyance to the respondent and affect the quality of responses. That is also why in the questionnaire the different types of each product have not been proposed, for example, the body moisturizing care product could have been divided in: milk, lotion, cream, oil.

In the study part on exposure, the choice was made to focus on 2 products, body moisturizers and anti-stretchmark care whose consumption was most likely to be varied during pregnancy. Indeed, during pregnancy, the skin is subject to alterations, such as the appearance of stretch marks on different parts of the body, which may require greater use of these 2 products, resulting in a change in exposure.

Studied population: No sampling plan was set up for this study. Participants were recruited thanks to the deployment of posters and flyers in gynecologic offices or maternity wards who have agreed to contribute to the study. More than 80% of the recruited population live in the north of France, and an over-representation of socio-professional categories is also observed, such as the "executive or equivalent" who represented 37.2% of the panel whereas they represent only 18.4 % of the French general population [13]. Thus, the panel of this study is not representative of the French pregnant women population. This over-representation of the higher socio-professional category may have affected the results. As this population has higher incomes than other categories, it is less limited in terms of purchasing new products, which could have an important influence on the consumption data collected. Due to technical constraints as volunteers had to bring their products to Euro safe to have them weighed, the panel of the complementary study on exposure came only from the "Ille-et-Vilaine" department. The findings of this study are therefore based on a small panel of French pregnant women. Indeed, it is difficult to recruit pregnant women for a survey of this kind, as they have many other concerns,

such as, first maternity for some, preparation of the child's arrival, etc.

Data Collection: The data collection has been performed via a web-questionnaire which is a quick way to collect data and the least constraining for the respondents especially when recruitment is on a voluntary basis and participants not remunerated. When completing the survey, women were in their pregnant period, indeed, the responses given on their consumption outside this period are based on a recall which can lead to a bias in the answers. For a future study it might be interesting to recruit pregnant women and to follow them during their pregnancy and after to have them answered the same questionnaire at different times as it has been done by *Lang, et al.* [11].

Usage Patterns of Cosmetic Products Outside and During Pregnancy

The data collected through the survey allow to compare usage pattern of personal care products during and outside the period of pregnancy.

Percentages of users: The prevalence of use before and during pregnancy for the 37 products investigated have been compared. A variation of ±5% has been observed for 19 of the cosmetics among which 6 presented a decrease or increase of more than 10%. This result demonstrates that pregnancy has a real influence on consumption of cosmetic products. Bust care and anti-stretchmark care were the cosmetics presenting the highest increase of users during pregnancy, with respectively a gain of 21.6% and 65.3% of users. This point is coherent with the fact that the bust is a body area undergoing pregnancy-related changes and that striae distensae is one of the most common alterations of the skin due to pregnancy [3]. 4 products presented a loss of users of more than 10%, i.e., nail polish (-23.6%), nail polish remover (-21.6%), perfume (-13.1%) and face care mask (-13.1%). An explanation for the loss of users of nail polish/remover and perfume may be the strong smell of those products and the abnormal smell perception experienced by a large majority of pregnant women [14]. It is also to be noted that for all the make-up products investigated, 6% of women stopped the use of those product during pregnancy and logically the prevalence of use of make-up remover also declines (-5.5%). It therefore seems that pregnant women are abandoning cosmetics that have a purely aesthetic function and not a care function.

Frequencies of use: As for the prevalence of use, variation of the frequencies of use have been observed between the pregnancy and non-pregnancy period for different personal care products. A statistically significant increase of the frequency of use has been highlighted for 6 products during pregnancy. These rises of daily applications concerned 3 body care products for which the average frequencies have gone from 0.88 to 1.22 day^{-1} for moisturizing care, 0.51 to 1.03 day^{-1} for bust care and 0.20 to 0.65 day^{-1} for massage oil, toothpaste with a slight growth from 1.94 to 1.99 day^{-1} and finally the 2 sunscreen products with an augmentation from 2.02 to 2.46 day^{-1} for face sunscreen and from 2.05 to 2.47 day^{-1} for body sunscreen. Those results highlight the special attention that pregnant women pay to their skin comfort during pregnancy, the protection against UV and their buccal hygiene. The increase of frequency of use of moisturizers is coherent with the results of another study [15]. Inversely, as for the percentage of users, the cosmetics mainly concerned by a decrease in their daily use by pregnant women are the "less necessary" ones, i.e., those having more a beautifying than a care function. Thus, the 4 make-up products, the make-up remover and the 2 perfuming products are the ones whose daily use decreases the most during pregnancy.

Purchasing place and selection criteria: No inversion in shopping place preferences was observed between pregnancy and non-pregnancy periods. However, some pregnant women change their habits since an augmentation of women buying cosmetics in drugstore while pregnant has been highlighted particularly for oral care, sun care and hygiene products. Another change in consumption noticed during pregnancy is the increased importance of "Natural ingredients" as the first selection criteria for cosmetics and the entry of safety into the main selection criteria. This last point is in accordance with the publication of *Marie, et al.* [10], where it was found that one of the new criteria of choice of cosmetics during pregnancy was "safe product ingredients" [10].

Comparison With Literature

Some data on consumption habits of personal care products by pregnant women are available in the literature. However, it is quite difficult to perform real comparisons between studies. First, when pregnant women are the purpose of studies, those are mainly developed to obtain data on the presence of some chemicals in urinary samples [4-6,16]. Since they are epidemiological studies, their main purpose is not the collection of cosmetic consumption data. Thus, those studies provide only few data on consumption of cosmetics, mainly percentage of users, when trying to establish a correlation between the presence of certain chemical molecules (phthalates, phenols.) in urine of pregnant women and the consumption of products such as food, drug treatments or cosmetics. Our study, by contrast, focuses on the analysis of a possible causal link between pregnancy and changes in cosmetic consumption habits. This allows a more complete and refined data collection about usage patterns of cosmetic products by pregnant women.

Secondly, the difficulties of comparison are also due to the disparities of personal care products' names, categories, and the clustering of products. For example, this study investigates the product "hair styling" which is quite a general term much more corresponding to a category, whereas *Ficheux, et al.* [9], investigates "lacquer", "gel", "foam", "wax" and "spray pump" which are more specific products. Another example is the "soap" product of our study which can be considered as a cluster since it regroups different products such as liquid soap and bar soap which are considered separately in the studies of *Braun, et al.* [4] and *Meeker, et al.* [16].

Beyond the differences in the objectives of these studies and the disparities in product names, a review of percentage of users of cosmetic products among pregnant women extracted from 6 papers is presented in Table 7. For 14 cosmetics investigated in our study the prevalence of use obtained is quite equivalent (differences <10%) in at least one of those studies. For example, the percentage of users of hair conditioner is of 67.3% in our study and of 63%, 69.8% (weekday), 58% and 63% respectively in *Ficheux, et al.* [9], *Lang, et al.* [11], *Buckley, et al.* [5], and *Brau,n et al.* [4]. A summary of frequencies of use available in the literature have also been performed and is presented in Table 8. The frequencies are issued of 2 papers of *Ficheux, et al.* [9], and *Lang, et al.* [11], who carried out consumption studies on pregnant women. It appears that for 12 cosmetic products considering in our survey, the frequencies of use collected are close to data collected by *Ficheux, et al.* [9] or *Lang, et al.* [11]. As examples, for the face cleansing gel, the mean frequency of use is the same in the *Ficheux, et al.* [9], and in our study: 0.94 day^{-1}. The deodorant is used on average 1.10 times per day in the present study, 1.13 times per day in *Ficheux, et al.* [9], and 1.2 times per day in *Lang, et al.* [11].

Table 7: Prevalence of use of cosmetic products among pregnant women in the literature.

	This study		Ficheux et al. 2015		Lang et al. 2016			Just et al. 2010		Buckley et al. 2012		Braun et al. 2014		Meeker et al. 2013	
	N=199		Consumption study		Consumption study			Study on phthalates		Study on phthalates		Study on phthalates		Study on phenols/ parabens	
			12 months recall		24 hours recall			48 hours recall		48 hours recall		24 hours recall		48 hours recall	
			N=251		N=80			N=186		N=50		N=177		N=105	
	Product	**Users (%)**	**Product**	**Users (%)**	**Product**	**Users (%) (Weekday)**	**Users (%) (Weekend)**	**Product**	**Users (%)**	**Product**	**Users (%)**	**Product**	**Users (%)**	**Product**	**Users (%)**
Body hygiene	**Shower gel**	**91.5**	**Shower gel**	**92**											
	Soap	46.2	Solid soap	31	Body soap	85.7	79.1					Bar soap	67	Bar soap	94.3
								Liquid soap	29			Liquid soap	85	Liquid soap	98.1
	Intimate hygiene	**55.8**	**Intimate hygiene**	**63**											
	Deodorant	**92**	Deodorant aerosol	48	Deodorant/ antiperspirants	77.8	62.7	**Deodorant**	**98**			**Deodorant**	**84**		
Body care	Moisturizing care	92	Moisturizing milk	58	Body lotions/ creams/oils	65.1	74.6	Lotion	82			Lotion	72	Hand/ body lotion	90.5
	Bust care	32.2	Bust cream	12											
	Anti-stretchmark care	70.9	Anti-stretchmark cream	50											
	Slimming care	1.5	Slimming cream/gel	18											
	Massage oil	30.7	Massage oil	52											
	Hand cream	63.3	Hand moisturizer	76						Hand cream/ lotion	86				
	Foot cream	24.1	Foot moisturizer	47											
	Nail polish	44.7						Nail polish/ remover	10			Nail Polish	4	Nail Polish	55.2
	Nail polish remover	42.2			Nail polish remover	0	1.5								

Perfuming	Eau de toilette	36.2	Eau de toilette	49	Fragrances/ perfumed products	14.3	10.5			**Cologne/ perfume**	**56**	Cologne/ perfume	31	Per-fume/ cologne	88.6
	Perfume	**64.3**	**Perfume**	**69**				Perfume	41						
Face hygiene	Cleansing gel	53.3	Soap free gel cleanser	29						Cleansing cream	42				
	Soap	**13.1**	**Solid soap**	**20**											
	Exfoliating scrub	**46.2**	**Exfoliating scrub**	**51**											
	Make-up remover	73.4	Make-up remover lotion	61											
Face care	**Moisturizing care**	**79.4**	**Moisturizer**	**80**											
	Eye contour	**28.6**	**Eye contour**	**32**											
	Mask	**39.7**	**Mask**	**43**						Facial mask	14				
Face make-up	**Foundation**	**61.8**	**Cream foundation**	**42**						**Founda-tion**	**54**				
	Mascara	**78.4**	**Mascara**	**83**	Eye make-up and cosmetics	47.6	14.9			Eye shadow/ liner/ mascara	66				
	Eye pencil	**55.3**	**Eye pencil**	**64**											
	Lipstick	52.3	Lipstick	63	Lip products	31.8	34.3			Lipstick	84				
Hair	**Shampoo**	**100**	**Liquid shampoo**	**99**	Shampoo	87.3	83.6					Shampoo	76	Sham-poo	92.4
	Conditioner	**67.3**	**Conditioner**	**63**	**Conditioner**	**69.8**	**67.2**			**Hair con-ditioner**	**58**		**63**	Condi-tioner	92.4
	Hair styling	23.1	Lacquer	33	Hair styling	38.1	32.8			Hair styling gel/ mousse pomade/ grease	66				
			Gel	19				Hair gel	25			Hair gel	42		
			Foam	23											
			Wax	14											
			Spray (pump)	22				Hair spray	10					Hair-spray	44.8
Oral care	Toothpaste	100	Toothpaste	62											
	Mouthwash	27.6	Mouthwash	43										Mouth-wash	76.2
Sun	Sunscreen	91.5								Sun-screen	10	Sun lotion	14	Sun-screen	4.8

Products in bold are considered to have equivalent prevalence of use (difference < 10%)

Table 8: Frequencies of use of cosmetic products by pregnant women available in the literature

	This study			Ficheux et al. 2015			Lang et al. 2016		
	Product	Frequency of use (day-1)		Product	Frequency of use (day^{-1})		Product	Frequency of use (day^{-1})	
		Mean	SD		Mean	SD		Mean	SD
Body hygiene	**Shower gel**	**0.94**	**0.40**	**Shower gel**	**1.03**	**0.44**			
	Soap	**1.44**	**1.31**	Solid soap	1.15	0.71	**Body soap**	**1.3**	**0.7**
	Intimate hygiene	**0.91**	**0.61**	**Intimate hygiene**	**0.96**	**0.52**			
	Deodorant	**1.10**	**0.57**	**Deodorant aerosol**	**1.13**	**0.56**	**Deodorant / antiperspirants**	**1.2**	**0.4**
Body care	Moisturizing care	1.22	0.72	Moisturizing milk	0.72	0.52	Body lotions / creams /oils	2.4	1.6
	Bust care	1.03	0.83	Bust cream	0.83	0.65			
	Anti-stretchmark care	1.17	0.67	Anti-stretchmark cream	0.96	0.61			
	Massage oil	0.65	0.52	Massage oil	0.10	0.09			
	Hand cream	**0.81**	**1.00**	**Hand Moisturizer**	**0.83**	**0.67**			
	Foot cream	0.34	0.50	Foot Moisturizer	0.51	0.48			
Perfuming	Eau de toilette	0.73	0.49	Eau de toilette	0.88	0.49			
	Perfume	0.68	0.45	Perfume	0.98	0.51			
Face hygiene	**Cleansing gel**	**0.94**	**0.58**	**Soap free gel cleanser**	**0.94**	**0.60**	Soap / cleansers / washes	1.4	0.9
	Soap	0.85	0.55	Solid soap	1.21	0.68			
	Exfoliating scrub	0.13	0.15	Exfoliating scrub	0.29	0.39			
	Make-up remover	**0.81**	**0.48**	**Make-up remover lotion**	**0.88**	**0.46**			
Face care	**Moisturizing care**	**1.09**	**0.59**	**Moisturizer**	**1.06**	**0.40**	Lotion/ creams	1.7	1.0
	Eye contour	0.81	0.62	Eye contour	0.94	0.63			
	Mask	**0.07**	**0.06**	**Mask**	**0.09**	**0.06**			
Face make-up	**Foundation**	**0.65**	**0.38**	**Cream foundation**	**0.71**	**0.49**			
	Mascara	0.67	0.41	Mascara	0.80	0.48	Eye make-up and cosmetics	2.3	1.1
	Eye pencil	0.59	0.43	Eye pencil	0.73	0.52			
	Lipstick	0.56	0.70	Lipstick	0.81	0.66	Lip products	1.6	1.0
Hair	Shampoo	0.43	0.24	Liquid shampoo	0.53	0.40	Shampoo	1.1	0.3
	Conditioner	**0.32**	**0.24**	**Conditionner**	**0.37**	**0.31**	Conditionner	1.0	0.2
	Hair styling	**0.44**	**0.35**	**Lacquer (aerosol)**	**0.45**	**0.43**			
				Gel	**0.52**	**0.44**			
				Foam	**0.41**	**0.42**			
				Wax	**0.43**	**0.46**			
				Spray (pump)	**0.47**	**0.46**			
	Hair dye	**0.02**	**0.01**	**Hair dye**	**0.02**	**0.01**			
Oral care	Toothpaste	1.99	0.58	Toothpaste	1.61	0.58			
	Mouthwash	0.41	0.61	Mouthwash	0.77	0.70			

Products in bold are considered to have equivalent frequency of use (difference < 10%)

The differences observed in terms of percentage of users and frequency of use can be explained by differences in methodology. The survey of the present study asks pregnant women about their actual consumption but is based on a recall for the period before pregnancy, whereas the study of Ficheux et al. [9] is based on a recall for the past 12 months. The other studies used recall methods over much shorter periods of times, *Meeker, et al.* [16], *Buckley, et al.* [5], and *Just, et al.* [6], used the method of the 48 hours recall and *Braun, et al.* [4], and *Lang, et al.* [11], 24 hours recall. Such disparities in the collection of the data have an impact, particularly on the prevalence of use of some products not intended to be used daily, such as nail polish or nail polish remover. In the same way for sunscreen product, the period of the year during which the investigation was conducted is of importance due to the close link between sunscreen use and sun exposure.

In the present study, exposure of pregnant women to body moisturizers and anti-stretchmark care have been assessed. Quantity data of body milk moisturizers and anti-stretchmark care applied by pregnant women have also been published by *Bavoux, et al.* [17]. The mean amount per day obtained was 16.4g/day with a P90 value of 29.6g/day for milk moisturizers [17], which is 7-fold more for the mean and 9.5-fold more for P90 than our results. Similarly, quantity data obtained by *Bavoux, et al.* [17], for anti-stretchmark care were 9-fold higher for the mean (18.8g/day) and 8-fold higher for the P90 (31.2g/day). As the methodology used by *Bavoux, et al.* [17], is not well described, it is difficult to explain such disparities.

Exposure of pregnant women to milk body moisturizers and anti-stretchmark care have previously been assessed in France [18]. The mean exposure obtained in Ficheux and Roudot [18] for milk body moisturizers was 44.3mg/kg bw/day (P90=108.6mg/kg bw/day) which is higher than our results (mean=35.68mg/kg bw/day; P90=61.18mg/kg bw/day). Similarly, exposure obtained in Ficheux and Roudot [18] for anti-stretchmark care was higher than in the present study: mean of 74.00 VS 31.75mg/kg bw/day and P90 of 171.12 VS 60.91mg/kg bw/day. However, it must be noted that quantities used by Ficheux and Roudot [18] for the exposure assessment of pregnant women were amount applied by non-pregnant women.

The quantity of body moisturizers obtained in this study and the related exposure are lower than the actual values given by the Scientific Committee on Consumer Safety (SCCS) for the general population for body lotion. The P90 amount value given by the SCCS is 7.82g/day and an associated P90 exposure value of 123.2mg/kg bw/day [19], whereas the P90 amount value of the most exposed pregnant women in our study, who are those in their 3rd trimester of pregnancy, is 6.65g/day and an associated P90 exposure value of 94.88mg/kg bw/day. The values given by the SCCS are those published by *Hall, et al.* [20] and refer to amount and exposure to body lotion for male and female whereas the target population of our study is the very specific one of pregnant women. They refer to a single galenic form of body moisturizer which is the lotion, whereas the body moisturizers used by the members of our study's panel are of different galenic forms i.e., oil, cream, milk, or balm. This implies different densities for these products, which can therefore have an impact on the quantity of product applied and thus exposure, as a denser product weighs more. In addition, products such as milk or oil are more easily spread on the body than a balm which can also affect the amount applied.

In addition to the differences in terms of population and galenic forms, the visible differences between our values and those of *Hall, et al.* [20] could be explained by the areas of application of the products. Indeed, in our study, body moisturizers were used on an extensive body area depending on the person. While some pregnant women applied them only to relatively limited areas, for example the belly, or the thighs and belly, others applied them to the whole body. In the study of *Hall, et al.* [20] there is no reference about an area of application.

An important result of this study is that women in their 3rd trimester of pregnancy use more body moisturizers and anti-stretchmark care than women in their 2nd trimester, thus inducing a more important exposure. Therefore, beyond the fact that there are disparities in consumption of cosmetics between pregnant and non-pregnant women, it appears that there is also a variability in the consumption of cosmetic products and in the related exposure inside pregnant women population depending on the trimester of pregnancy.

The results of this study were obtained on a limited and very specific panel of French pregnant women. Even if this panel is not representative of the French pregnant women population, the data generated could be useful for the evaluation of the safety of cosmetic products for this population. However, it will be up to the risk assessors to determine whether these data can be extrapolated and used for other European populations.

Conclusion

Pregnant women are considered as a population at risk, thus a specific risk assessment based on accurate consumption and exposure data is needed for each cosmetic product intended to be used by this population. However, pregnant women remain for the moment poorly represented in consumption studies and the available data remain insufficient. This population is difficult to include in surveys, on the one hand because it is a sensitive

population that one does not dare disturb too much, and on the other hand because pregnancy lasts 9 months, thus limiting the time window to carry out the survey. The data generated thanks to this study increase the actual knowledge on the consumption behavior of pregnant women. Indeed, this work has shown that there are significant changes in the consumption of certain cosmetic products during pregnancy. The consideration of these changes and the frequencies data generated will allow performing more accurate safety assessments. This study also provides new exposure values of two body care products commonly used during the pregnancy and highlights that there are disparities in consumption and exposure to cosmetic product depending on the stage of pregnancy. It will be interesting to continue this work on other products for which consumption changes have been identified with a larger panel to allow a better assessment of exposure according to trimester of pregnancy.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

1. EU (2009) Regulation (EC) No 1223/2009 of the European Parliament and of the Council of 30 November 2009 on cosmetic products.
2. Muzaffar F, Hussain I, Haroon TS (1998) Physiologic skin changes during pregnancy: a study of 140 cases. Int J Dermatol 37(6): 429-431.
3. Nussbaum R, Benedetto AV (2006) Cosmetic aspects of pregnancy. Clin Dermatol 24(2): 133-141.
4. Braun JM, Just AC, Williams PL, Smith KW, Calafat AM, et al. (2014) Personal care product use and urinary phthalate metabolite and paraben concentrations during pregnancy among women from a fertility clinic. J Expo Sci Environ Epidemiol 24(5): 459-466.
5. Buckley JP, Palmieri RT, Matuszewski JM, Herring AH, Baird DD, et al. (2012) Consumer product exposures associated with urinary phthalate levels in pregnant women. J Expo Sci Environ Epidemiol 22(5): 468-475.
6. Just AC, Adibi JJ, Rundle AG, Calafat AM, Camann DE, et al. (2010) Urinary and air phthalate concentrations and self-reported use of personal care products among minority pregnant women in New York city. J Expo Sci Environ Epidemiol 20(7): 625-633.
7. Li H, Zheng J, Wang H, Huang G, Huang Q, et al. (2019) Maternal cosmetics use during pregnancy and risks of adverse outcomes: a prospective cohort study. Sci Rep 9(1): 8030.
8. Parlett LE, Calafat AM, Swan SH (2013) Women's exposure to phthalates in relation to use of personal care products. J Expo Sci Environ Epidemiol 23(2): 197-206.
9. Ficheux AS, Wesolek N, Chevillotte G, Roudot AC (2015) Consumption of cosmetic products by the French population. First part: Frequency data. Food Chem Toxicol 78: 159-169.
10. Marie C, Cabut S, Vendittelli F, Sauvant Rochat MP (2016) Changes in Cosmetics Use during Pregnancy and Risk Perception by Women. Int J Environ Res Public Health 13(4): 383.
11. Lang C, Fisher M, Neisa A, MacKinnon L, Kuchta S, et al. (2016) Personal Care Product Use in Pregnancy and the Postpartum Period: Implications for Exposure Assessment. Int J Environ Res Public Health 13(1): 105.
12. EPA (2001) Chapter 3: using probabilistic analysis in Human health assessment. Process Conduct. Probabilistic Risk Assess. 1-27 US.
13. INSEE (2018) Socio-professional category by sex and age in 2018 Insee.
14. Nordin S, Daniel A Broman, Jonas K Olofsson, Marianne Wulff (2004) A Longitudinal Descriptive Study of Self-reported Abnormal Smell and Taste Perception in Pregnant Women. Chem Senses 29(5): 391-402.
15. Bernard L, Pélissier M, Kouame N, Marie C, Lémery D, et al. (2018) Use of cosmetics during the pregnancy and risk perception by French pregnant women. Eur J Public Health 28(suppl_4): cky218-037.
16. Meeker JD, Cantonwine DE, Rivera González LO, Ferguson KK, Mukherjee B, et al. (2013) Distribution, Variability, and Predictors of Urinary Concentrations of Phenols and Parabens among Pregnant Women in Puerto Rico. Environ Sci Technol 47(7): 3439-3447.
17. Bavoux C, Picot V, Roudot A, Verdier C, Sater N, et al. (2011) Pregnant women exposure assessment to cosmetic products. Toxicol Lett 205: S255-S256.
18. Ficheux AS, Roudot AC (2017) Exposure of the French population to cosmetic products. Consumer chemical risk assessment laboratory (LERCCo) Breast France.
19. SCCS (2018) SCCS Notes of Guidance for the Testing of Cosmetic Ingredients and their Safety Evaluation 10th revision. SCCS/1602/18.
20. Hall B, Tozer S, Safford B, Coroama M, Steiling W, et al. (2007) European consumer exposure to cosmetic products, a framework for conducting population exposure assessments. Food Chem Toxicol 45(11): 2097-2108.