



# Health-related quality of life 1 year after a large-scale industrial fire among exposed inhabitants of Rouen, France: ‘The Post Fire 76 Health’ study

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**Background:** A large-scale industrial fire occurred in Rouen, France, in 2019. This study assessed the health-related quality of life of people exposed to its consequences 1 year later. **Methods:** The study population comprised inhabitants of the exposed area and a non-exposed area. A representative sample was randomly selected using a stratified design. Data were collected using a standardized questionnaire to describe fire exposure and to calculate three health-related quality of life scores according to the SF12-v2 scale. After adjustment, descriptive and multivariate analyses were conducted. **Results:** The sample comprised 4773 participants (response rate 47.7%). In the exposed area, the average mental, physical and overall health scores were 47.5, 52.0 and 73.8 out of 100, respectively. Mean mental and overall health scores were higher in the non-exposed area (49.0 and 76.0, respectively). After adjustment, a lower mental health score was associated with a higher number of perceived types of exposure, reaching –3.72 points [–5.41; –2.04] for five or more different types of perceived exposure. A lower mental health score was associated with soot deposits (–1.04 [–1.70; –0.39]), perceiving odours [(–2.04 [–3.22; –0.86]) up to the day of data collection], and having seen, heard or been awakened by the fire (–1.21 [–1.90; –0.52]). A slightly lower physical health score was associated with soot deposits (–0.57 [–1.07; –0.08]). **Conclusion:** This study highlighted associations between exposure to the consequences of the industrial fire in Rouen and a deterioration of perceived health-related quality of life 1 year later, particularly the mental health dimension.

## Introduction

On 26 September 2019, a large-scale industrial fire occurred in the warehouses of two companies in Rouen, France. As a result, a massive black smoke plume developed, and spread over several kilometres in a north-easterly direction, covering the regions of Normandy and Hauts-de-France. Approximately 9500 tons of chemical substances and various materials were burned, causing huge flames and barrel explosions. Debris from a smashed fibrocement roof was scattered over the surrounding area. The fire was extinguished nearly 12 h later. However, a smouldering fire lasted for some days. Soot deposits were observed after the fire, in addition to unpleasant persistent odours.<sup>1</sup>

Fortunately, no related deaths or injuries were reported. Local medical practitioners reported an increase in psychological disorders following the incident, including anxiety and stress.<sup>2</sup> As a consequence, a medico-psychological unit was dispatched to help people in the days following the fire.<sup>3</sup> During the month that followed the fire, a local epidemiological surveillance investigation was conducted.<sup>4</sup> It highlighted a small increase in emergency care consultations for asthma and dyspnoea, as well as numerous reports to the local air quality monitoring organization regarding odours associated with otorhinolaryngological and ocular symptoms, bronchopulmonary irritation, general illness, and digestive tract disorders.

Several studies have highlighted the physical and mental health impact on people exposed to industrial or natural accidents.<sup>5,6</sup> Belleville et al.<sup>5</sup> showed that 1 year after the wildfires in Fort McMurray, Canada, in 2016, 38% of adult evacuees had a probable diagnosis of either post-traumatic stress, major depression, insomnia, generalized anxiety, or substance use disorder, or a combination of these conditions. Tjalvin et al.<sup>6</sup> suggested that a year and a half after an oil tank explosion in western Norway in 2007, exposed workers had a higher Subjective Health Complaints Inventory score, and reported more self-reported mental and physical complaints than non-exposed workers.

The physical and mental health impacts of disasters can persist over the long term<sup>7</sup> and exposure is associated with lower health-related quality of life (HRQL).<sup>8,9</sup> A study conducted in Galicia, northwest Spain, showed that 1 year after the Prestige oil spill in 2002, residents living near the accident area, and those who were more exposed to the accident, had a lower mental health HRQL dimension score.<sup>8</sup> Another study, also conducted in 2002, showed that 1 year after the World Trade Center Disaster and the subsequent American Airlines Flight 587 crash in 2001, exposure to cumulative disasters was associated with lower HRQL scores for general health, mental health and bodily pain.<sup>9</sup> Other studies also highlighted the importance of assessing perceived health in areas affected by local environmental pollution.<sup>10–14</sup>

To our knowledge, few studies to date have assessed the impact of industrial fires or technological accidents on the HRQL of an exposed population, especially in the medium term. In order to assess the health impact of the fire in Rouen, an epidemiological surveillance tool called "The Post Fire 76 Health—"A study that listens to your health"—was implemented among the general population in the affected area.<sup>15,16</sup> The present analysis aimed to assess the associations between exposure to the fire and HRQL in the medium term (i.e. 1 year after the accident), as part of the cross-sectional study included in this tool.

## Methods

### Study area and population

'The Post Fire 76 Health' study took place in two areas of the Seine-Maritime department (a sub-regional administrative area) of the Normandy administrative region (Appendix 1). To make comparative analyses, the exposed area—the city of Rouen and its surroundings—was compared with a non-exposed area. For the latter, the city of Le Havre and its surroundings, located 70 kilometres northwest of Rouen, was chosen, because of its comparability in terms of territory and socioeconomic characteristics.<sup>17</sup>

In order to take into account the various types of exposure to the accident, geographical stratification was implemented on the exposed area based on environmental observations (Appendix 1). Four geographical strata were defined as follows: (i) a 'proximity' stratum, defined by a geographic criterion (0–700 and 700–1500 m from the site of the fire); (ii) a 'South-West' stratum, which covered the municipalities where at least six unpleasant odour complaints were reported in the 2 months following the fire<sup>18</sup>; (iii) a 'Far North-East' stratum, which covered the area directly under the plume of black smoke generated by the fire; (iv) a 'Close North-East' stratum, which covered all municipalities that met the inclusion criteria of strata (ii) and (iii). The exposed and non-exposed population included all adults residing in the exposed and non-exposed areas, respectively.

### Sampling procedure

The Survey Division of the National Institute of Statistics and Economic (Insee) randomly selected a representative sample from the 2019 edition of the national fiscal database called "The Demographic Files on Households and Individuals" (Fidéli).<sup>19</sup> A simple random sampling procedure was used to select one adult per household from each of the four exposure strata described above.<sup>17</sup> In total, a random sample of 10 777 adults—7999 in the exposed area and 2778 in the non-exposed area—were contacted to participate in the survey.

### Data collection

Data collection was conducted between September and December 2020, 1 year after the industrial fire, using a standardized questionnaire. Participants were invited to complete the questionnaire online (self-administration) or by phone with a professional interviewer.

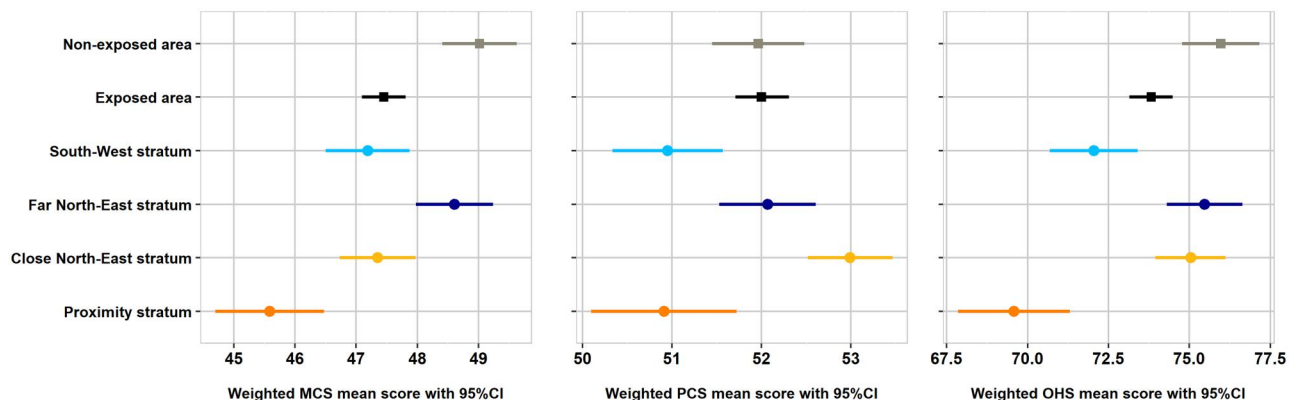
One section of the questionnaire focused in detail on participants' exposure to the fire and its aftermath. The elements covered included perceiving odours and the duration of this perception, being located under the plume of black smoke and the duration of this exposure, observing soot deposits around their home, having directly seen the flames or the location of the fire, hearing the effects of the fire, and the presence of fibrocement roof debris in their surrounding environment. The residential area (exposed/non-exposed indicator variable) and the distance from the participant's home to the industrial site where the fire occurred were also assessed as exposure variables.

HRQL was assessed for participants in the exposed and non-exposed areas using the French validated version of the 12-item version of the Medical Outcomes Study—Short Form Health Survey (SF-12v2).<sup>20,21</sup> This instrument assesses self-reported HRQL over the preceding four weeks, by measuring eight domains as follows: physical functioning, physical role, bodily pain, general health, vitality, social functioning, emotional role, and mental health. From these, two scores are calculated: the Physical Component Summary (PCS) and the Mental Component Summary (MCS). Each of these scores ranges from 0 to 100 (the higher the value, the better is the perceived health state). For the purposes of this study, an unadjusted Overall Health Score (OHS) was also constructed by summing the 12 items of the SF-12v2, scaled also from 0 to 100.

The confounding variables were either provided by the Fidéli sampling database<sup>19</sup> or declared by the participants in the survey questionnaire. They included socio-demographic factors (age at the time of data collection, gender, number of adults in the household, length of time living in the region, housing occupation status and social housing residence), socioeconomic factors (education level, perceived financial situation, disposable household income in deciles, socio-professional status, socio-professional category and employment status), self-reported health and lifestyle-related factors [pre-existing chronic disease, body mass index (BMI), smoking status, alcohol and tobacco consumption, social isolation, professional relationship with one of the involved companies], and three coronavirus disease (COVID-19)-related variables (possible COVID-19 infection, having had a difficult COVID-19-related lockdown experience, concerns about the COVID-19 pandemic).

### Statistical analyses

In order to reflect the studied population as accurately as possible, all statistical data analyses took into account the study sampling design.



**Figure 1** SF-12v2 scores of the participants per area (exposed/non-exposed) and per stratum (SouthWest/Far North-East/Close North-East/Proximity) (weighted mean, 95% confidence interval [95% CI],  $N = 4773$ ). MCS, mental component summary; PCS, physical component summary; OHS, overall health score. "The Post Fire 76 Health—"A study that listens to your health".

Very few missing data were observed ( $\approx 2\%$ ) and were replaced using the multivariate imputation by chained equations method (MICE).<sup>17,22</sup>

In the descriptive analysis, the categorical variables were described by weighted percentages and their 95% confidence intervals (95% CI). Quantitative variables were described by their means and their 95% CI. The mean values of the three HRQL scores, along with their corresponding 95% CI, were depicted for each stratum.

Linear regression models with Gaussian distribution were used for the multivariate analysis. First, the SF-12v2 scores of participants in the exposed and non-exposed areas were compared. Second, the associations between the number of perceived exposures related to the fire and the three HRQL scores were analyzed for participants in the exposed area. Moreover, we assessed the associations between the types of perceived exposures (as described above) and the three scores of the SF-12v2 for participants in the exposed area.

We used the Akaike Information Criterion (AIC) for model selection. Some variables were forced into the models [age, gender, perceived financial situation, education level, social housing, number of adults in the household (for the three HRQL scores), social isolation (for the MCS only) and possible COVID-19 infection (for the PCS only)]. Interactions between the variables were also tested. The absence of collinearity between the variables included in the model was verified using the variance inflation factor (VIF).

Statistical analyses were performed using the 'survey' package in R software 4.0.4 and SAS software 7.1.

### **Ethical considerations**

The survey received approval from the French council for statistical information (CNIS, no. 178/H03) and the Committee of Public Statistics (No. 2020\_17077\_DG75-L002). Personal data processing was performed in compliance with the General Data Protection Regulation (GDPR). Specifically, data collection was based on the participants' consent (article 9.2.1 GDPR) and only pseudonymized data were used for the analyses.

## **Results**

### **Descriptive results**

The study sample comprised 4773 adults (3758 in the exposed area and 1015 in the non-exposed area), corresponding to a participation rate of 47.7% (50.2% and 40.2%, respectively). Two-thirds (64.3%) of the participants used self-administered the questionnaire online.

The main socio-demographic, socioeconomic, self-reported health and lifestyle, and COVID-19-related factors of both populations are presented in [table 1](#). Half (53.2%) of the exposed population were women and mean age was 49.3 ( $\pm 0.4$ ) years. Overall, the characteristics of both populations were similar, although the exposed population had a higher level of education, higher socio-professional jobs, and were more concerned by the COVID-19 pandemic. Additional descriptive analyses are presented in [Appendix 2](#).

One year after the industrial fire, the mean MCS score of the exposed population was lower than that for the non-exposed population [47.5 (95% CI: 47.1; 47.8) vs. 49.0 (95% CI: 48.4; 49.6)]. Participants living in the proximity stratum had a lower MCS score [45.6 (95% CI: 44.7; 46.5)] than those living in more distant locations.

The observed mean PCS score was similar in both populations [(52.0 95% CI: 51.7; 52.3) and (52.0 95% CI: 51.4; 52.5) for those exposed and non-exposed, respectively], and was slightly lower among participants in the proximity stratum [50.9 (95% CI: 50.1; 51.7)].

The mean OHS was lower in the exposed population [73.8 (95% CI: 73.2; 74.5) vs. (76.0 95% CI: 74.8; 77.2)]. Participants in the proximity stratum had a lower mean OHS [69.6 (95% CI: 67.9; 71.3)] than participants in other strata ([figure 1](#)).

## **Multivariate analysis results**

### **Mental health**

The mean MCS score of the non-exposed area was slightly higher than that of the exposed area, with a significant difference of 0.69 points ([table 2](#)).

Perceiving two, three, four and five or more exposures in the exposed area was significantly associated with a lower MCS score than not perceiving any exposure, with a difference of 1.73, 2.24, 3.10 and 3.72 points, respectively.

In the exposed area, observing soot deposits around one's home was statistically associated with a lower MCS score (difference of 1.04 points), compared with not perceiving soot deposits. Perceiving odours related to the fire for the modalities for 'several weeks' and 'up to the day of data collection' were significantly associated with a lower MCS score compared with not perceiving these odours (difference of 1.65 points and of 2.04 points, respectively).

Having heard, seen or been awakened by the fire was associated with a lower MCS score (difference of 1.21 points) ([table 3](#)).

### **Physical health**

No significant difference was observed between the exposed and the non-exposed areas concerning the PCS score ([table 2](#)). Furthermore, no significant associations were observed between the perceived number of exposures related to the fire and the PCS score ([table 3](#)).

When assessing the types of exposures in the exposed area, only exposure to soot deposits was significantly associated with a slightly lower PCS score (difference of 0.57 points) ([table 3](#)).

### **Overall health**

No difference for the OHS was observed when comparing the exposed and non-exposed areas ([table 2](#)).

On the contrary, perceiving three, four, and five or more exposures related to the fire in the exposed area was significantly associated with a lower OHS than not perceiving any exposure (difference of 2.47, 5.29, and 6.27 points, respectively) ([table 3](#)).

Observing soot deposits around one's home was significantly related to lower mean OHS, (difference of 2.30 points). Participants, who perceived odours up to the day of data collection had a lower OHS (mean difference of 2.73 points) compared with participants who did not perceive odours. Finally, having heard, seen or been awakened by the fire was associated with a significantly lower OHS (difference of 2.37 points) ([table 3](#)).

## **Discussion**

This study aimed to assess the HRQL of people exposed to the consequences of a large-scale industrial fire in the medium term. Our results suggest that 1 year after the event, experiencing several types of exposure, smelling odours (especially for a long time), observing soot deposits around one's home, and having heard, seen, or been awakened by the accident, were all negatively associated with participants' HRQL. This result is most probably due to an impact on participants' mental health, which was evaluated with the MCS score of the SF-12v2.

The HRQL scores for inhabitants in the proximity stratum were lower than those for inhabitants in the other three strata. This can be explained by the fact that people residing near the site of the fire may have experienced the consequences of the fire more intensely and/or for a longer duration. They may also have had a lower socioeconomic level and more difficulties in coping with this kind of situation. These possibilities echo existing literature and underline the importance of the impact of this type of an accident on HRQL and in particular on the mental health component, despite the fact that no related deaths or injuries were reported.<sup>8,23,24</sup>

**Table 1** Socio-demographic, socioeconomic, self-reported health and lifestyle, and COVID-19-related characteristics of participants in the exposed and non-exposed populations (N = 4773) 'The Post Fire 76 Health—“A study that listens to your health”'

	Exposed population		Non-exposed population	
	n	% [95% CI]	n	% [95% CI]
Gender				
Man	1703	46.8 [45.0; 48.7]	461	48.2 [44.9; 51.5]
Woman	2061	53.2 [51.3; 55.0]	554	51.8 [48.5; 55.1]
Level of education				
No schooling	449	13.3 [12.0; 14.7]	135	16.1 [13.5; 18.7]
Vocational training certificate	475	13.5 [12.3; 14.8]	146	15.0 [12.6; 17.4]
Middle-school diploma	378	10.1 [8.9; 11.2]	141	13.8 [11.5; 16.0]
High-school diploma	738	18.6 [17.2; 20.1]	216	20.8 [18.2; 23.4]
Post-secondary school diploma to 2-year third-level diploma	615	14.4 [13.2; 15.6]	173	16.6 [14.1; 19.0]
Bachelor's to Doctorate degree	1109	30.0 [28.4; 31.6]	204	17.8 [15.4; 20.2]
Perceived financial comfort				
Comfortable	668	17.9 [16.6; 19.3]	188	17.3 [14.8; 19.7]
Getting by	1431	36.2 [34.4; 37.9]	442	42.3 [39.0; 45.5]
Just getting by, need to be careful	1129	34.1 [32.3; 35.8]	286	29.4 [26.3; 32.4]
Cannot make ends meet without going into debt	436	11.9 [10.6; 13.1]	99	11.1 [8.9; 13.3]
Smoking status				
Daily smoker	614	16.3 [14.9; 17.7]	158	16.6 [14.1; 19.2]
Occasional smoker	279	7.1 [6.1; 8.0]	52	5.5 [4.0; 7.1]
Ex-smoker	884	22.9 [21.4; 24.4]	247	22.9 [20.2; 25.6]
Non-smoker	1987	53.7 [51.9; 55.6]	558	54.9 [51.6; 58.2]
Alcohol consumption				
Daily	181	5.5 [4.6; 6.4]	69	6.8 [5.9; 7.6]
4–6 times per week	115	3.1 [2.5; 3.7]	34	3.3 [2.1; 4.5]
2–3 times per week	559	14.4 [13.2; 15.7]	148	13.4 [11.3; 15.6]
Once per week	239	6.6 [5.7; 7.5]	74	7.3 [5.6; 9.1]
One or several times per month	1006	25.7 [24.1; 27.3]	259	23.9 [21.1; 26.6]
Less than once per month	648	17.9 [16.5; 19.3]	169	18.1 [15.4; 20.7]
Never	1016	26.8 [25.1; 28.4]	262	27.2 [24.2; 30.2]
Social isolation				
Feeling very alone/alone	534	14.9 [13.6; 16.3]	109	11.6 [9.4; 13.8]
Feeling supported/very supported	3230	85.1 [83.7; 86.5]	906	88.4 [86.2; 90.59]
Possible COVID-19 infection				
No	2987	79.5 [78.0; 80.9]	827	81.2 [78.5; 83.8]
Yes, not certain	350	9.2 [8.2; 10.3]	69	6.8 [5.1; 8.5]
Yes, certain	67	1.6 [1.2; 2.1]	14	1.1 [0.5; 1.7]
Don't know/refuse to answer	360	9.7 [8.6; 10.8]	105	10.9 [8.8; 13.0]
Difficult COVID-19-related lockdown experience				
Not difficult or a little difficult	1258	33.4 [31.7; 35.2]	406	39.8 [36.5; 40.0]
Moderately difficult	1527	41.0 [39.2; 42.9]	384	37.0 [33.9; 40.2]
Very difficult	979	25.5 [23.9; 27.2]	225	23.2 [20.3; 26.0]
Concerns about the COVID-19 pandemic				
Not or a little concerned	499	13.5 [12.2; 14.7]	147	14.2 [11.9; 16.4]
Moderately concerned	1687	44.2 [42.4; 46.0]	509	49.6 [46.3; 52.9]
Very concerned	1578	42.4 [40.4; 44.2]	359	36.3 [33.0; 39.5]
	Mean	SD of mean	Mean	SD of mean
Age (years)	49.3	0.4	50.1	0.7

n, number of participants; %, weighted percentages; [95% CI], 95% confidence interval.

### Mental health

The present study showed that participants in the exposed area had a significantly lower MCS score than persons in the non-exposed area one year after the fire. This result is consistent with data from various scientific studies showing the health impact of catastrophic events and their consequences on mental health in the short, medium and long terms.<sup>7,24–26</sup>

A lower MCS score was strongly associated with the number of perceived exposures to the fire. Specifically, reporting two or more exposures was associated with a significantly and monotonously lower MCS score. These results are also in line with existing literature which shows an association between the intensity or number of exposures and the risk of psychopathology, usually a dose–response type relationship.<sup>8,25,27,28</sup>

Observing soot deposits around one's home was associated with a lower MCS score. Seeing soot highlighted the quantity of pollution generated by the fire and its persistence in the environment, even

after the dispersion of the plume of black smoke. This experience may have worried inhabitants, thereby creating a negative effect on the exposed population's mental health.

A lower MCS score was also associated with perceiving unpleasant odours 'for several weeks' and 'up to the day of data collection. This result is also consistent with the scientific literature. The olfactory sense is linked to the emotional system.<sup>29</sup> Mental health disorders such as anxiety and depression have previously been associated with the duration of residence in an environment with unpleasant odours and olfactory discomfort.<sup>11</sup> A study conducted following the 2010 Deepwater Horizon oil spill in the Gulf of Mexico also showed that exposure to odours was associated with depression.<sup>30</sup>

In our study, participants who reported seeing or hearing the fire had a lower MCS score than those who did not. This reflects findings in a study conducted among residents of Fort McMurray 18 months following the 2016 wildfires, showed a significant association between witnessing burning homes and depression.<sup>31</sup>



**Table 2** Adjusted comparisons of SF-12v2 scores between participants in the exposed and non-exposed area ( $N=4773$ ) 'The Post Fire 76 Health—"A study that listens to your health"'

	MCS		PCS		OHS	
	Regression coefficient [95% CI] <sup>a</sup>	P-value <sup>a</sup>	Regression coefficient [95% CI] <sup>b</sup>	P-value <sup>b</sup>	Regression coefficient [95% CI] <sup>c</sup>	P-value <sup>c</sup>
Exposed/NON-exposed area						
Participants in the exposed area	Reference		Reference		Reference	
Participants in the non-exposed area	0.69 [0.05; 1.34]	0.036	0.08 [-0.43; 0.59]	0.771	0.98 [-0.20; 2.16]	0.104

MCS, mental component summary; PCS, physical component summary; OHS, overall health score.

a: Adjusted for age, gender, number of adults in the household, length of time living in the region, social housing, education level, perceived financial situation, pre-existing chronic disease, BMI, social isolation, possible COVID-19 infection, having had a difficult COVID-19-related lockdown experience, and having concerns about the COVID-19 pandemic.

b: Adjusted for age, gender, number of adults in the household, social housing, education level, perceived financial situation, BMI, pre-existing chronic disease, smoking status, alcohol consumption, social isolation, and possible COVID-19 infection.

c: Adjusted for age, gender, number of adults in the household, length of time living in the region, social housing, education level, perceived financial situation, BMI, pre-existing chronic disease, smoking status, alcohol consumption, social isolation, possible COVID-19 infection, having had a difficult COVID-19-related lockdown experience, and having concerns about the COVID-19 pandemic.

**Table 3** Associations between the number of perceived exposures related to the fire and the SF-12v2 scores and associations between the various types of perceived exposures related to the fire and the SF-12v2 scores in the exposed area ( $n=3758$ ) 'The Post Fire 76 Health—"A study that listens to your health"'

	MCS		PCS		OHS	
	Regression coefficient [95% CI] <sup>a</sup>	P-value <sup>a</sup>	Regression coefficient [95% CI] <sup>b</sup>	P-value <sup>b</sup>	Regression coefficient [95% CI] <sup>c</sup>	P-value <sup>c</sup>
Number of perceived exposures in the exposed area						
None	Reference		Reference		Reference	
One	-1.04 [-2.40; 0.32]	0.133	0.85 [-0.31; 2.02]	0.151	0.07 [-2.33; 2.47]	0.954
Two	-1.73 [-3.08; -0.38]	0.012	0.54 [-0.63; 1.70]	0.367	-1.35 [-3.68; 0.99]	0.258
Three	-2.24 [-3.64; -0.85]	0.002	0.29 [-0.88; 1.46]	0.625	-2.47 [-4.91; -0.04]	0.047
Four	-3.10 [-4.68; -1.52]	<0.0001	-0.76 [-2.05; 0.52]	0.245	-5.29 [-8.00; -2.57]	0.0001
Five or more	-3.72 [-5.41; -2.04]	<0.0001	-0.81 [-2.17; 0.56]	0.247	-6.27 [-9.18; -3.35]	<0.0001
Observing soot deposits around one's home						
No	Reference		Reference		Reference	
Yes	-1.04 [-1.70; -0.39]	0.002	-0.57 [-1.07; -0.08]	0.024	-2.30 [-3.42; -1.17]	<0.0001
Duration of exposure to odours						
None	Reference		-	-	Reference	
A few hours	-0.83 [-2.48; 0.83]	0.329	-	-	0.28 [-2.73; 3.29]	0.856
Several days	-0.76 [-1.86; 0.34]	0.176	-	-	-0.31 [-2.28; 1.66]	0.758
Several weeks	-1.65 [-2.73; -0.57]	0.003	-	-	-1.58 [-3.52; 0.35]	0.109
Several months	-1.12 [-2.27; 0.04]	0.059	-	-	-1.59 [-3.66; 0.48]	0.132
Up to the day of data collection	-2.04 [-3.22; -0.86]	0.001	-	-	-2.73 [-4.84; -0.63]	0.011
Heard, seen or been awakened by the fire						
No	Reference		Reference		Reference	
Yes	-1.21 [-1.90; -0.52]	0.001	-0.47 [-0.98; 0.03]	0.068	-2.37 [-3.56; -1.18]	0.0001

MCS, mental component summary; PCS, physical component summary; OHS, overall health score.

a: Adjusted for age, gender, number of adults in the household, length of time living in the region, social housing, education level, perceived financial situation, BMI, pre-existing chronic disease, social isolation, possible COVID-19 infection, having had a difficult COVID-19-related lockdown experience, and having concerns about the COVID-19 pandemic.

b: Adjusted for age, gender, number of adults in the household, social housing, education level, perceived financial situation, BMI, pre-existing chronic disease, smoking status, alcohol consumption, social isolation and possible COVID-19 infection.

c: Adjusted for age, gender, number of adults in the household, length of time living in the region, social housing, education level, perceived financial situation, BMI, pre-existing chronic disease, smoking status, alcohol consumption, social isolation, possible COVID-19 infection, having had a difficult COVID-19-related lockdown experience, and having concerns about the COVID-19 pandemic.

### Physical health

We found no significant association between either the number or type of exposure to the fire and physical health 1 year after the event, assessed using the PCS from the SF-12v2. The only exception was for people who observed soot deposits around their home. This subgroup had a slightly lower PCS score (-0.57 points) than people who did not observe soot deposits.

The presence of soot deposits could be an indicator of the level of exposure to fumes whether visible or not. Globally, air pollution may be associated with effects on physical health.<sup>32,33</sup> Exposure to soot deposits and the duration of exposure to chemical pollution and environmental nuisances from the fire may probably not have been sufficient to cause physical problems detectable in the medium term by our study, which was exclusively based on self-reported

health. The absence of significant results on perceived physical health might also be explained by the fact that this industrial accident did not lead to injuries likely to induce physical sequelae.

### Overall health

Observing soot deposits and having heard, seen or been awakened by the fire were associated with a lower OHS. In addition, the OHS gradually decreased as the number of perceived nuisances and the duration of perceived odours increased.

Considering the respective effects of perceived exposure to the industrial fire on the MCS and PCS, this overall deterioration in health was mainly due to the negative impact we observed on mental health.

Our study has several limitations. First, because of its cross-sectional design, no causal relationships between exposure to the fire and HRQL could be established. This limitation likely reflects bidirectional associations. Second, data collection occurred 1 year after the industrial fire. Hence, accounts of perceived exposures were susceptible to recall bias, although the latter is limited in the context of large-scale disasters and accidents. Residents close to the fire area may have overestimated the intensity of their exposure and/or the effects of the fire.<sup>34</sup> However, the SF-12v2 survey looks at the 4 weeks preceding a study interview, which limits recall bias for HRQL measures.<sup>20,21</sup> Finally, data may have been subject to desirability bias for participants who completed the questionnaire by phone with the assistance of a professional interviewer.<sup>35</sup>

There are also several study strengths. First, the sampling strategies, the number of people included, and the statistical analyses used made it possible to obtain a representative sample and to reach good statistical power.<sup>17</sup> Second, besides defining geographical strata, we assessed the exposure not only by using binary variables, but also by evaluating the duration of certain exposures. This approach acknowledges the difficulties of measuring different exposures after a disaster.<sup>36</sup> Third, the literature has highlighted the effect of the COVID-19 pandemic on mental and physical health.<sup>37,38</sup> In our study, by including a non-exposed population, we were able to take this potential effect into consideration and to compare the results with the exposed population. Fourth, we used a validated psychometric scale to measure participants’ HRQL. This meant that we could reliably assess participants’ self-perceived health.<sup>20,21</sup> The monotonous dose–response associations we found between a lower MCS score and a higher number of exposures reflect the potential impact of this fire on exposed people’s health. Finally, the consistency of the results obtained, as well as the observed deterioration of mental health but not physical health, as one might have expected for this accident, underlines the internal validity of our study.

In conclusion, the present study highlighted significant associations between the number and types of exposures related to the industrial fire in Rouen in September 2019 and the local population’s HRQL, mainly the mental health dimension, 1 year after the event.

These associations underline the importance of assessing medium term HRQL and self-perceived health—especially the mental dimension—following such an event.

Furthermore, our results highlight various actions to implement when preparing an effective response to similar future industrial accidents. These include: (i) paying particular attention to residents near the accident, (ii) training health professionals on the toxic and psychological effects observed after such events, (iii) taking into account all exposures, in particular odours, in the communication and the health management of the event, (iv) informing health professionals during the event about known exposures, observed health effects and their management, and finally, (v) informing the general population about all potential effects and actions to take in the event of such an accident.<sup>16</sup>

## Supplementary data

Supplementary data are available at *EURPUB* online.

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## Data availability

Data are available upon request from the authors.

*Conflicts of interest:* None declared.

## Key points

- The large-scale industrial fire in 2019 in Rouen, France, had a negative impact on HRQL observed 1 year later in the exposed population, especially for inhabitants who were close to the site of fire when it occurred.
- The deterioration of mental and overall health in persons in the exposed area was monotonously associated with the number of perceived exposures.
- Perceiving odours (especially over a long time), observing soot deposits around one’s home, and having seen, heard or been awakened by the fire, were all negatively associated with the mental health dimension of quality of life in people living in the exposed area.
- Only observing soot deposits around one’s home was associated with a slightly lower physical health score among inhabitants of the exposed area.
- Several actions could be taken when future similar industrial accidents occur such as paying particular attention to residents near the accident, training health professionals on the potential toxic and psychological effects, and taking into account all exposures in communications to the general population, including perceptible exposures such as odours.

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